VAN NOSTRAND'S
ECLECTIC
ENGINEERING MAGAZINE.

No. XVIII.—JUNE, 1870.—Vol. II.

EXPERIMENTS UPON FORGED IRON BEAMS.*

The first portion of this valuable paper was devoted to a description of an iron shield to an experimental casemate at Fort Monroe, with the result of some firings in October, 1868, at which time the shield was employed as a target.

The standards forming the backing to the target were wrought-iron uprights having a section of 12 by 15 in.

From the character and extent of the rupture under the heavy firing, it was impossible to estimate what amount of resistance the standards had really offered to bending or breaking. It was generally believed to have been much less than formula, founded upon assumed elastic extension of the fibres, would authorize us to assign them. Experienced iron manufacturers suggested that the highly crystalline appearance of the surfaces of fracture was caused by the instantaneousness of the rupture; others believed that it was common to *all* large forgings, and created during the slow cooling from welding heat; while still others attributed it to bad workmanship.

It was thought that it would be instructive to break one or more of these beams under the slow pressure of a hydraulic press. For that purpose, two were brought from Fort Monroe to the Brooklyn Navy Yard, one of which was the only sound one remaining in the casemate shield; the other came from the "open embrasure" target.

The composition of the iron, and its conversion into bars for forging, are thus described by the manufacturer:

* * * * * * *

"The iron was made of the following brands of pig-iron: Three-fourths Lake Superior charcoal, made by the Morgan Iron Company, at their old furnace near Marquette, Michigan. The blast, I suppose, ought to be called *warm*. The intensely hot blast now in use had not been introduced into that region at the time this iron was purchased, several years ago.

"The other one-fourth was of anthracite hot-blast iron, made at the Donegal furnace, in the Juniata region, Penn. I adopted this mixture of metals, as we found, after numerous trials of other irons, this to be the best for making blooms, of which to make galvanized iron. This requires a most superior iron, soft and malleable when cold. These qualities I judged were most desirable for armor plating.

* * * * * * *

"The pig-iron is converted into wrought-iron by the usual method of puddling or boiling—from the furnace taken to the squeezers and formed into a lump, and then at the same heat rolled into bars of $\frac{3}{4}$ in. to 1 in. in thickness, and 4, 6, and 8 in. wide.

* * * * * * *

*From a paper read before the American Society of Civil Engineers, February 7, 1870, by Brevet Major-General J. G. Barnard, U. S. Corps of Engineers, Member of the Society.

"The bars thus formed were forged together into the beams under a 4-ton moving cylinder (Condie) hammer falling 5 ft. 9 in."

* * * * * * *

The diagram and following table will give the facts of the first experiment :

Flexure in inches.	Tons of 2,000 lbs. pressure.	
$\frac{1}{4}$	430	
$\frac{3}{8}$	500	
$\frac{1}{2}$	553	
$\frac{5}{8}$	584	
$\frac{3}{4}$	584	
$\frac{7}{8}$	597	
1	599.6	
$1\frac{1}{8}$	645	Two small cracks noticed on the face of the beam, at top, right of fulcrum.
$1\frac{1}{4}$	645.8	
$1\frac{3}{8}$	645.8	
$1\frac{1}{2}$	661	
$1\frac{5}{8}$	676	
$1\frac{3}{4}$	676	
$1\frac{7}{8}$	692	
$1\frac{15}{16}$	707	
2	707	
$2\frac{1}{8}$	738	
$2\frac{1}{4}$	753	
$2\frac{1}{2}$	769	
$2\frac{3}{4}$	784	Broke across, as shown in sketch, the fracture being highly crystalline —the crystals being largest in the centre.
3	799	
$3\frac{1}{4}$	799.8	

The first recorded flexure of $\frac{1}{4}$ in. gives a calculated strain per square inch of the upper external fibres 36,792 lbs. ; an elongation of the same of .00382 ; and a corresponding coefficient of elasticity of 9,558,600 lbs. (for inch unit).

The seventh entry in the table shows a flexure of one inch under a pressure of 600 tons.

The corresponding tension of outer fibre is	51,508 lbs.
The corresponding extension of outer fibre is	0.0154 "
The corresponding coefficient of elasticity is	3,334,511 "

The last entry but one shows a flexure of three inches under a pressure of 800 tons, for which we have :

Tension per square inch of outer fibres	68,450 lbs.
Extension of outer fibres	0.0463 "
Corresponding coefficient of elasticity	1,482,000 "

* The experiments were conducted by Brig.-Gen. C. B. Reese, U. S. Corps of Engineers.

The flexure of $3\frac{1}{4}$ inches produced rupture without any indication of increased pressure; and it will be observed that there are several stages in which the flexure thus increases. The press worked slowly—was frequently stopped (the whole time of experiment being 15 to 20 minutes), and when stopped the pressure became relaxed. On renewing it the flexure increased before the pressure gauge regained its lost elevation. Time had, *perhaps*, considerable to do in producing so great a flexure of the iron. Nevertheless, the strength of the iron is very great; and, for so large a beam, the extension of fibre is extraordinary.

The "permanent set" extended only 15 inches each way, from the place of fracture. At the limit of "set" the strain was equal to what would be produced at the middle point by a load of 400 tons, multiplied by $\frac{38.5-15}{3.85} = 242$ tons. This weight is about a mean between those required to produce deflexions of $\frac{1}{4}$ and $\frac{1}{2}$ an inch. It corresponds to a strain on the external fibres of 41,391 lbs., and an elongation in .005. But a remarkable feature in the "permanent set" is exhibited in the *cross section*. The base is permanently expanded $\frac{1}{2}$ an inch, while the top is contracted or shortened $\frac{1}{8}$ of an inch, by which the section of fracture has acquired a trapezoidal figure; a strong collateral proof of the ductility and toughness of the iron.

It must be borne in mind, however, that the above calculations suppose that, at the same moment, the coefficient of elasticity is uniform throughout the beam. We see, however, that the coefficient rapidly diminishes as the extension increases, and hence it must be very much less in the more extended outer fibres than in those near the neutral axis. Moreover, it is probable that it does *not* so decrease for increased compression; and hence the neutral axis will fall below the middle of the beam. This last effect is indicated, too, by the change in the section; the area of the portion below the middle line becoming about $\frac{1}{3\frac{1}{2}}$ larger than that above it. The above figures for breaking tension must, from all these causes, be somewhat too high.

On the 25th of May the second beam was subjected to the same test. It was manufactured about six months earlier

than the one first described, but there is no known difference in the material or process of manufacture. The statement herewith, will give the particulars of the experiment. Though the breaking pressure proved to be identically the same as before, the flexure was but 1 inch instead of 3¼ inches. That is to say, the tensile strength was as before, 68,450 lbs. per square inch; but this corresponded to an "elongation" of fibre but 0.0154, while the coefficient of elasticity was 5,446,000 instead of 3,334,511 lbs., the coefficient furnished by a corresponding extension in the first beam. No "permanent set" either in figure or cross section was observed. In this case there was no stoppage of the force pump, and the power was applied as rapidly as possible, the rupture taking place in about 2½ minutes.

Flexure in inches.	Tons pressure (of 2,000 lbs.)	
½	615	
¼	707	
⅛	767	
1 (short)	799	Broke across, as shown in sketch; the fracture being highly crystalline.

In this experiment the pressure was applied as rapidly as possible, and the beam broke in about 2½ minutes after commencing the experiment.

In all cases, whether the beams were broken by the intantaneous shock of the projectile, or by the comparatively slowly applied pressure of the press, the fracture was throughout highly crystalline. I do not think that there is any decided distinction between the results of the two processes. In the last beam broken the cleavage surface of the crystals was larger and the fracture more ragged than in the first. Around the outer margins of both, the fractured surfaces were much finer-grained (approximating in the first beam to the appearance of *very* coarse sand-paper) than at the central portions. The largest cleavage surfaces may be ⅛ to ¼ square inch in area—though such are rare. The second beam, more highly crystalline than the first, had less ductility (*i. e.*, was more brittle), yet its breaking strain was not impaired.

As the foregoing calculations could not, for the reasons stated, be implicitly relied on, it was important to determine the tensile strength by direct experiments. Two specimens were taken from each of the beams—one of which was heated and hammered, and drawn down to proper size—the others tested just as they came from the beam. (These last were taken from the central and most crystalline portion of the forgings.) The results are as follows:

	Tensile Strength.
No. 1. First beam, reworked specimen,	63 413 lbs.
No. 2. Second beam " "	67.846 "
No. 3. First beam, unworked "	53.953 "
No. 4. Second beam " "	57.786 "

The fracture of No. 1 was what is called "fibrous," that is, fine-grained and dark, when looked at directly, but lustrous under certain lights, and what is usually considered as indicating a superior iron.

The central part of No. 2 (say about one-third) had the same appearance as No. 1, though inferior; all the rest, say two-thirds of the surface, was highly crystalline, and not finer-grained than *some parts* of the fracture of the original beam.

Of No. 3, the fracture was very similar to that of No. 1, though less lustrous.

The fracture of No. 4 exhibited over a segment comprising about one-third of the circular area, a fine-grained fracture, but darker, and destitute of lustre; the rest of the surface was highly crystalline, yet less coarsely grained, if there was a difference, than the crystalline parts of No. 3.

It is to be observed that the real tensile strength of the iron *in the beam* (as given in Nos. 3 and 4) was in the one case 20, in the other 15 per cent. less than that deduced from calculation; that the process of reworking gives about an equal increment in the two cases. The difference in the two beams may be owing to variations in the character of pig-iron coming from the same sources, or from varying time and heat in the forgings.

The tensile strength exhibited by these beams was above the *average* for wrought-iron in bars, while the reworked specimens are equal to the average of a large number of specimens of Burden iron, and approach in strength the best irons

a a, bearings of steel. *b*, piece of steel 1″ wide on top.

Scale $\frac{1}{2}'' = 1$ foot.

known, as will be seen from the following figures :

Major Wade gives (1845) strength of different irons thus :

Russian iron (in flat bars)...	62.644	lbs. per sq. in.
Bankes' (English) ...	56.532	"
Low Moor " ...	56.103	"
Bridgewater (Am.) iron...	48.488	lbs. per sq. in.
" "	49.338	"
Salisbury iron is given by Prof. W. R. Johnston at...	58.009	"
And charcoal refined Lake Superior at.....	89.582	"

The Ordnance Manual gives for—

Bar iron.....	57.000	lbs. per sq. in.
Salisbury iron.....	57.000	"
Swedish iron.....	72.000	"

Kirkaldy says: The breaking strain per square inch of wrought-iron is generally stated to be about 25 tons for bars and 20 tons for plates. This corresponds very nearly with the writer's experiments, of which the following table presents a condensed summary :

	Highest.	Lowest.	Mean.
	Lbs.	Lbs.	Lbs.
188 bars, rolled.....	68.848	44.584	57.555
72 angle-iron, etc.....	63.715	37.909	54.729
167 plates, lengthways.....	62.544	37.474	50.737
160 " crossways.....	60.756	32.450	46.171

The extension, especially of the first beam (one-twentieth, nearly), though far beneath that sometimes exhibited by small rods or wires, is very remarkable, when the dimensions of the forgings and the highly crystalline structure of the iron are considered.

It is highly probable that so great extension of fibre as these experiments developed did not take place in the beams ruptured by the firings. Though identical with the experimental beams in composition and manner of fabric, not the slightest trace of "set," so strikingly exhibited by the first beam, could be observed in them. That the forgings were excellent may be inferred from the absence of appearances of seams or flaws in the fractures, and from the rupture occurring exactly at the middle point. The engineers and master mechanics of the Navy Yard, and other experienced operators in iron, regarded them as "of most excellent quality of workmanship, having the clearest and most solid appearance of any bars they had seen."

The results show neither high tensile strength nor a considerable ductility to be incompatible with the process of "forging" in large masses ; and that iron of a highly crystalline structure (the usual result of such forging) may possess these qualities ; that, in common with iron so prepared as to possess the maximum of ductility, it does not exhibit that quality to its full extent when the rupturing shock is instantaneous.

Hence the iron supports of shields should be of such a character (*e. g.* built-up beams) that the necessary yielding may take place by *warping* rather than extension of fibre ; or, on the other haud, should be such as to involve *no extension whatever* —the target, by means of arched backing or something of the kind, being made perfectly rigid and the shot made to expend *all* its work, instead of at least nine-tenths (as it inevitably must do), *upon the indentation.*

On the 14th of August a beam of the sam dimensions, cast vertically, from the same pig-irons, in the same proportions, and allowed to remain in the mould until thoroughly cool, was broken in the press.

The results were as follows :

Flexure $\frac{1}{4}$ in.,.....Pressure, 183 tons.
" $\frac{3}{4}$ " ..... " 276 "

At which flexure the beam broke.

From whence by calculation we should get for a flexure of $\frac{1}{4}$ in. :

Tension per sq. in. of outer fibres, ...15.640 lbs.
Extension of fibre,.....00.382 "

And for a flexure of $\frac{3}{4}$ in.:

Tension of outer fibre (that of rupture) 23.615 lbs.
Extension of fibre..... 00.53 "

A specimen of iron from this beam was tested for tensile strength and found to have 16.067 lbs., or about 33 per cent. less than deduced above.

It was believed that better results might be obtained, and the iron was remelted in a reverberatory furnace, 4½ hours being occupied in the melting, the casting remaining 3 days in the mould.

This recast beam broke with a pressure

of 384 tons, with a flexure of $\frac{5}{16}$ in., which would give a calculated tensile strength of 32,850 lbs. A specimen of the iron of this beam was then tested for tensile strength; the result was 17,140 lbs. per sq. in., or not much over 50 per cent. of that which was obtained by calculation based on transverse strength.

A remark is here necessary in explanation of preceding calculations. The Ordnance Manual, p. 436, gives the following expression (to be found in all works on the strength of materials) for the breaking weight of a rectangular beam supported at both ends and loaded in the middle:

$$W = 4\,S\frac{b\,d^2}{l}$$

in which W is the required weight, l the distance between the supports, b and d the horizontal and vertical dimensions of the section. If the law of elasticity upon which the theory is based held good, that is if the "co-efficient of elasticity" remained constant for all degrees of extension and was identically the same *for compression*, the co-efficient S would be *one-sixth the tensile strength of the material*. As it is the outer and upper fibres only which are extended to rupture when the beam gives way, we should therefore have, calling T the tensile of those fibres, or of the material:

$$T = \frac{3}{2}\,W\frac{l}{bd^2}$$

More generally if W′ is any weight (*less* than the breaking weight W), supported at the middle, and R the tensile strain thus produced upon the outer fibres, we should have

$$R = \frac{3}{2}\,W'\frac{l}{b\,d^2}$$

It is thus that I have calculated the "tension of outer fibre" for different stages of the experiments—there being, in fact, no other way. I have already remarked upon the inaccuracy of this calculation when it is applied to great extensions or to strains approaching rupture. In fact, the assumptions of constancy in the coefficient of elasticity and of its identity for compression and extension, however convenient, are well known to be in opposition to the results of experiment. In Morin's Table (p. 8, "Resistance de Materiaux") the coefficient of extension for wrought-iron is, at the state approaching rupture, but about $\frac{1}{3}\frac{1}{3}$ of what it is at the beginning.* On the other hand, the co-efficients for compression and extension are not identical. Hence, as the fibres along the section of rupture are in all stages of extension, from a maximum at the upper fibre down to zero at the neutral axis, and thence have increasing degrees of compression to the lower surface, such formula can give but inaccurate results. Nor can they approach to much accuracy when the co-efficient, S, as applied to breaking strains, is determined by experiments; for the results are extremely variable, depending on the character of the iron and the form of the section. In the three instances given in the Ordnance Manual for "cast-iron," S varies from $\frac{1}{4}$ to $\frac{2}{3}$ the given tensile strength of the material. In the single case given for "bar iron" it is but little over $\frac{1}{2}$ of the corresponding tensile strength.

In the case of the forged iron beams experimented upon, the resulting value of S would be, for the first a little less, for the second a little greater, than $\frac{1}{2}$ the strength which direct experiments proved to belong to the "unworked" iron of the beams.

In the case of castings, in the first case S would approximate to $\frac{1}{4}$, in the second to $\frac{1}{3}$ the real tensile strength of the iron. In all these cases the ratio of these fractions to $\frac{1}{6}$ is the ratio by which the *calculated* exceed the true tensile strengths, as afterwards determined by direct experiment. The calculated "extension of fibre" does not err, necessarily, in the same direction. It does not, probably, exceed the real extension, and must, indeed, fall short of it if the neutral axis, through inequality in compression and extension, is lower than the assumed central position, as it probably is in all cases in which S exceeds $\frac{1}{6}$ T.

The average "tenacity" of cast-iron gun-metal, prior to 1841, is given
at.....23,638 per square in.
In 1851, it was.....37,774 " " "

The mean tensile strength of the iron of the 10-in. guns which endured 2,540 rounds each, was 26,038 lbs.

Although the *cast-iron* of these beams proves comparatively weak, the extensibility of the metal appears to be much

* The extreme extension in this Table does not exceed or even equal that which was found for the outer fibres of the first beam broken—viz., .0464.

greater than that of the gun-metal tested by General Rodman (p. 159, Experiments on Metals, etc.).

The fracture of the iron in the beam at first cast exhibited a leaden gray color and a crystalline structure quite uniform, but quite as coarse and *apparently* less close than that of Lake Superior charcoal pig-iron; the fracture of the re-cast beam showed greater compactness. The particular composition of iron used in these beams appears to be quite inferior as cast-iron to what it is when wrought.

Limited in scope as are these experiments, I think they furnish presumptive evidence of the superiority of forged wrought-iron, in large masses, over cast-iron, for ordinary transversal strains and for the endurance of shocks. The universal use of wrought-iron for shafts of steamships, etc., is in accordance with this conclusion; and if such observations as we could make at the firings furnish no proof that the elastic forces of the iron were fully called into play, yet the subsequent experiments go to show that neither the process of forging nor the crystalline structure which results from it is *necessarily* destructive of ductility and tenacity. If it appears, indeed, that even the most ductile and tenacious wrought-iron is, like cast-iron, *brittle* under the action of instantaneous applied rupturing strains, yet the presumption of superiority is certainly in favor of that material which possesses the above qualities in the highest degree.

The press, used under the direction of the able Naval Constructor, Mr. B. F. Delano, was one made in England, and set up in the Brooklyn Navy Yard, for the purpose of bending armor plates. Its gauge was graduated to 2,000 tons (of 2,000 lbs.), and the accuracy of its indications was thoroughly tested.

In relation to forged iron in masses of large dimensions (such as shafts of steamships, rolling mills, etc.), there is great diversity of opinion, and little experimental knowledge. That they frequently break is notorious. If it happens that a flaw in the forging is found, as is sometimes the case, the rupture is of course satisfactorily *explained*, even if it casts doubt upon the reliability of the forging process. But quite frequently no flaw is found (and the means and processes are so thoroughly perfected at the present day that there is no excuse for their occurring), while the sharply defined and highly crystalline fracture, which is invariably observed, is usually considered an indication of dangerous brittleness. The various explanations already mentioned as having been applied to the fracture, by gun-shot, of the beams in the target, are freely offered. Inconsistent with each other, experimental observation is almost wholly wanting to test their validity. Hence the experiments herein recorded, limited as they are, may prove of some value.

THE EFFECT OF TEMPERATURE ON COAL GAS.

From "Engineering."

Of the many experiments which have from time to time been made on the illuminating power of coal gas under different conditions, very few, we believe, have been conducted with a view of ascertaining the extent to which that power is affected by the temperature to which the gas is exposed, and for this reason some experiments of this kind, which were not long ago carried out in the laboratory of the University of Munich, possess a special interest. In these experiments the illuminating power of the gas at the normal temperature of 64½ deg. Fahr. was taken as the standard, and the object was to compare, by means of a Bunsen's photometer, this illuminating power with that obtainable when the gas was burnt in the same burner at a higher or lower temperature. In order that this might be done, the burner was attached to a U-tube, which could be immersed either in a cooling mixture or in a liquid at an elevated temperature. The illuminating power at the normal temperature being represented by 100, it was found that when the U-tube was immersed in snow, so as to bring the temperature of the gas down to 32°, the illuminating power was reduced to from 76 to 85; while when a mixture of salt and snow was used to give a temperature of—4 deg. the illuminating power

of the gas was reduced to from 33 to 40, or, in other words, it was only equal to about $\frac{1}{3}$ of that which it possessed at the normal temperature. Of course such a temperature as —4 deg. is one to which gas is never practically exposed, at all events, in this country; but the fact that even at a temperature of 32 deg. there was found to be an average diminution of the illuminating power to the extent of about 20 per cent. is an important one, well deserving of attention.

Heating the gas above its normal temperature was found to have far less influence upon its illuminating power than cooling it below that temperature, and this was a result which might have been expected, for reasons which we shall point out presently. By immersing the U-tube in boiling water, and thus raising the temperature of the gas to 212 deg., it was found that the illuminating power was increased to 104 (the illuminating power at the normal temperature being, as before, represented by 100), while when melted paraffine was substituted for the water, and the temperature thus increased to 288 deg., the illuminating power became 118. Thus while a reduction of temperature of about 32 deg. lessened the illuminating power by about 20 per cent., an increase of temperature of 224 deg. raised that power by about 18 per cent. only. This state of affairs is readily explicable if we suppose the reduction of temperature in the former case to have been sufficient to cause the liquefaction of a portion of the hydrocarbons associated with the gas, as in that case the total amount of sensible and latent heat abstracted from the gas by the reduction of temperature of 32 deg. might even be greater than that imparted to it when its temperature was raised to 288 deg. In all the experiments the air for supporting combustion was, we believe, supplied at the normal temperature; but it would have been interesting if, in the case where the gas was cooled to 32 deg. Fahr., the light had been supplied with air at that temperature also, and notice taken of the effect.

In the course of the experiments it was found that, after the gas had for some time traversed the tube immersed in the cooling mixture, a thick coating of ice was deposited on the interior of the tube. The water resulting from the melting of this ice had a strong smell, was neutral to test papers, but when exposed to suitable tests gave a feeble reaction, showing the presence of cyanogen. With indigo carmine (sulphindigotate of potass) and sulphuric acid, it developed the blue color of indigo, and evolved the odor of nitrobenzine. To determine the amount of water carried by the gas a large quantity of the latter was caused to pass very slowly through a drying tube charged with pieces of pumice-stone soaked in sulphuric acid. A large number of experiments made in this way on the ordinary gas supplied to Munich showed the quantity to average about 1.6 grains per cubic foot.

COKE IRON AND CHARCOAL IRON.

By M. BERTHAULT.

Translated from "Les Mondes."

What is the cause of the inferiority of coke iron to charcoal iron? And why is the charcoal iron of certain countries of Europe inferior to that of Sweden and Russia?

From my investigation of the composition of cokes and the coals which produce them, and of the woods of different kinds employed in Sweden and other countries of Europe, I have come to the conclusion that this inferiority proceeds mainly from the insufficiency of the salts of potassium and sodium which are employed in the fusion of the iron.

The following is from the extensive work of MM. Flachat, Barrault, and Petiet.

No. 137. Potassium, Sodium, Calcium.

These metals produce a decarbonizing effect upon the ore without combining with it; the potassium contained in the cinders of the combustibles does not appear in the slag or in the metal, but is volatilized so that it is found in great quantity upon the walls of blast furnaces.

Lime dissolves the silica contained in

ore, and, besides, sets free a large quantity of sulphur.

Bessemer and Heaton in their processes both base their system of reduction of ores upon the oxidizing reaction either of nitrate of soda or of nitrate of potassa.

The quantities of alkaline salts contained in various fuels are given by MM. Violette and Archambault, as follows:

ANALYSIS OF OAK ASHES.

Carbonic Acid,	28.2	
Sulphuric "	7.6	
Muriatic "	1.8	
Silica "	1.7	
Potassium,	33	60.7
Sodium,	27.7	
	100	

White Oak Ashes,	0.075	of Alkaline Salts.	
Chestnut "	0.146	"	"
Parisian Oak "	0.150	"	"
Pontgibaud "	0.200	"	"
Allevard Fir "	0.257	"	"
Norway Fir "	0.500	"	"

St. Etienne Coal, Ammoniacal Carbonate.
Auzin Coal, ... Ashes, Water, & Potassium, 0.128.
Chaulevay Coke, No Potassium.
English " } No Potassium, but Salts of
St. Etienne " } Lime, (Sulphuret and Carbo-
Rive-de-Gier " } nate).

It seems, then, to be demonstrated that the salts of potassium and sodium introduced into the blast furnace with the ore and the fuel, give, with coke or with other fuel, iron of superior quality. Everything depends on the quantity of potassium or sodium. The salt should be the carbonate of potassium, such as is obtained from vegetables, and known as raw potash, pearl ash, Russian or American potash, etc.

In order to obtain a uniform quality of iron in the same blast furnace or manufactory, in other words, to apply the proper quantities of the salts, they must be dissolved in some agglutinating mixture, and the ore, or rather the porous coke, must be covered with the compound; diluted clay or blood mixed with water will answer.

The question of expense is of course to be considered, but the expense will be compensated by the improved quality. Potash is still very dear; but it is probable that the water of salt marshes mixed with lime could be used. The high temperature would decompose this mixture and produce the necessary decarburant gas. By this means the greater part of the work now done in the puddling furnace or the Bessemer apparatus might be done in the blast furnace.

INFLUENCE OF RAIN ON FILTRATION OF RIVER WATER.

From "The Mechanics' Magazine."

Whether it is that we have so much and so general rain in England as to have, strictly speaking, no rainy season, or that the geological formation of our soil is essentially different, yet it is certain that we do not experience the same effects that attend the rivers of other countries at certain periods of the year. During the autumn and winter months our streams, especially those in mountainous districts, do become swollen and turbid to a very considerable degree, but still do not approach the condition of those in higher latitudes. As an example of a river which is affected perhaps to a maximum by the rainy season, we may select the Hooghly, or, as it may be appropriately termed, the river of Calcutta. A most valuable and interesting report on this subject has been published by W. Smith, Esq., C. E., Chief Engineer to the Calcutta Water Works. As it bears directly upon the welfare and interests of both the native and British population residing on the banks of the river, we shall proceed to discuss its contents with all the more alacrity since the condition of our own rivers and streams is a disgrace to a civilized nation. Our readers were made well acquainted with this fact in a recent article on the pollution of rivers, which was based on the indisputable assertions and statements contained in the lately issued report of the Royal Commission appointed to investigate and inquire into the whole bearings of the question. In whatever land a river may be situated, and under whatever circumstances it may be placed, the effect of heavy and sudden rains will be to cause flooding, and to surcharge the water with more or less solid matter. The nature of this solid addition materially influences the future state of the water, and the accomplishment of its

proper filtration. It is of course taken for granted that all water intended for the supply of cities and towns, from whatever source it may be derived, is passed through filtering beds before being permitted to flow into the delivery pipes. If, therefore, by reason of floods, the river or other source of supply become strongly impregnated with any substance which would tend to choke up or clog the filtering beds, it is manifest that the flow of the water would be very much impeded, the filter beds rapidly deteriorated, and the whole operation rendered increasingly troublesome and expensive. Such is thecase with the Hooghly. During the monsoon the river becomes charged with a very fine description of clay, which seriously increases the difficulty of filtration. In some experiments made upon small samples of the turbid water with an ordinary paper filter, it was found that even after settling for a considerable time, it either passed through in a partially muddy condition, or that a layer of clay formed on the filter, which would not allow any water to pass through at all.

The general condition of the Hooghly at the various periods of the year differs considerably. From November until March it is not sensibly contaminated with mud, and that which it does contain speedily subsides, leaving the water nearly clear. During the next four months it receives large additions of foreign substances and a great deal of mud; but the particles are coarse, and subside without much difficulty, so that the filtration is not impeded. From the end of June to the beginning of November is the trying time for the filtering beds, although it is not the quantity but the quality of the mud that is the objectionable feature in it. The fine clay that remains suspended in the water will not settle ; it will pass through a coarse filter, but forms, as has been already stated, an impervious layer or coating over the surface of a fine one. The object of the experiments to which we shall refer was to determine the best method of managing the filtering operations, and the most suitable materials to employ for the purpose. With this view, four filtering boxes were constructed of teak, and lined with sheet-zinc. Two of them were 6 ft. by 6 ft. by 6 ft., and two were 3 ft. by 2 ft. by 6 ft. deep. The other arrangements were common to all. They consisted of a small iron box fitted below the centre of the bottom, with an iron pipe passing below the bottom of the box to one side, and then passing upwards along that side. In addition, each box was supplied with a stopcock and various exit pipes at different heights, by which the flow of water could be regulated by the degree of pressure required. Four iron tanks, containing each 400 gallons, were placed at a higher level to act as settling reservoirs. These were furnished with siphons and stopcocks for drawing off the water to the filters after settlement had taken place. The filtering materials consisted of silicious pebbles, and gravel of different sizes, and of sand, some of which was coarse and some fine. The latter was obtained near Pultah, the former in the vicinity of Mugra, and one of the objects of the experiments was to determine their relative values as filters. It is not enough for a filtering bed to deliver the water in a state of purity, but it must also deliver it in a sufficient quantity for the supply demanded. A bed of Pultah sand 30 in. in thickness was proved to be able in a very short time to deliver the water free from mud, while a similar bed of Mugra sand 48 in. in thickness did not arrive at that stage until after the lapse nearly of a couple of months, during which time it yielded only about half the proper quantity of water. By exceptional management the coarser-grained sand can be made to deliver the muddy water clear, but the most careful management will not raise it to the standard of the other and finer description. It becomes seriously impaired in efficiency by an increase in the pressure of the water, and also by the pressure of the fine kind of clay which results from the flooding of the river.

Among the items constantly occurring in the working expenses of water-works, is the cleaning of the filtering beds, and this mainly depends upon two circumstances. One is the quality of the water supplied, and the other, the nature of the material used as a filter. If the bed become choked up so that the flow be intercepted, it must be attributed either to the foul condition of the water, or to the badness of the material, or perhaps to both. A remarkable distinction must be here noticed between the manner in which filtration proceeds when the water is very much impregnated with foreign particles, and

when it is comparatively pure. Under ordinary contingencies, the filtration and separation of foreign particles is effected by the first three or four inches of the bed, and the remainder of its depth remains nearly free from impurities. In a word, the filtration is accomplished by superficial aid alone, and does not penetrate much below the surface of the filter. This condition of affairs no longer prevails when the rainy season sets in. At any rate, it is not the case with the waters of the Hooghly. The fine clay suspended in it is not arrested by the uppermost layer of the filtering bed, but finds its way down to the bottom. In the experiments in question, different depths of sand were operated upon with the same result, although it was proved that the depth to which the clay penetrated depended upon several circumstances, such as the pressure, the consistency of the sand, and the rate of the flow. The proportion of the clay diminishes with the depth of penetration, as might be expected. There are two methods in ordinary use for cleaning the sand of filtering beds when it is needed. One is to wash the layer of sand with water, and the other, to remove it altogether and replace it by a clean stratum. Neither of these plans is recommended for filtering the Hooghly water, but it is proposed not to remove the dirty layer of sand until the whole bed requires a renewal. It is very justly argued that if the plan of removing the first three or four inches in thickness be adopted, there will always be in this case a clean layer on the top of one which is not clean, but which is to a certain extent impregnated with the peculiar fine clay described. The method recommended is to commence with a good thick bed which will last during the rainy season, and which will not require a thorough renewal until the process of filtration has returned to its normal condition, and the operation may be easily accomplished. No analogy can be fairly drawn with respect to the whole management of filtering beds in India from the manner in which they are treated at home. The conditions of the two cases are entirely different, and consequently different means must be resorted to in order to successfully carry out the various operations demanded.

TELEGRAPHS IN THE EAST.

From "Engineering."

The "Bombay Gazette" expresses its opinion that the world has gone mad on the subject of submarine telegraph cables, but supports its demand for one between Bombay and Galle, which is assumed will cost a mere bagatelle of £200,000,* and be more speedy and more certain than a land line.

Truly telegraph cables are in high favor just now, and the public, ignorant of or rejecting the lessons taught by numerous failures, and without first ascertaining if the same conditions apply, on the strength of the success of the Atlantic cables, are perhaps somewhat careless of the consequences of investing in any great scheme of submarine telegraphy.

There can be no doubt that there are still some good openings left for submarine telegraphs which offer fair prospects of being remunerative; but if the conditions under which submarine telegraphs pay, and pay better than land lines, be absent, success is impossible. We call attention at length to these matters because of their intense effect on the commerce of this country. Any scheme that is accepted by the public and fails, throws back telegraphic extension for years; witness the failure of the first Red Sea and the first Atlantic Cable. It will be too late when the day of repentance cometh—as come it must for the public, or the shareholders, or possibly both—to inquire why legislation did not intervene to insist on the adoption only of those routes which alone can offer reasonable prospects of providing good communication at the lowest possible price.

During the last year we have placed upon the market six or more schemes for extending telegraphic communication to China, Japan, and Australia. Some of these are on the direct line of communication, and all possess some good elements,

*It cannot be laid for less than £350,000, or possibly £450,000.

but not one of them is perfect or even approximates to perfection, excepting the submarine schemes chiefly promoted by the Telegraph Construction and Maintenance Company, who have adopted such a circuitous route that even if they earn a dividend they must expect to be cut out by any line or combination of lines which is sure to come forward to seize the shorter and what happens to be the stronger route.

The staple argument of the cable companies is, that cables work cheaper, better, and with greater speed than land lines; the correctness of this depends upon their relative length, and special condition of climate and place. On the Indian Government lines, messages are transmitted between the Presidency towns and Kurrachee with very great rapidity; they are, in fact, transmitted on well-insulated lines, without any repetition whatever over distances of nearly 1,800 miles.

Land lines cost less than one-third the price of cables, are easily repaired, permit of several wires, a much lighter speed of signalling, and generally offer alternative routes; such lines, repaired at intervals, last for ever, but as yet we know, but little of the longevity of cables, even when laid in very deep water. Our knowledge is almost limited to the cases published in the Blue Book of 1860 ("Construction of Submarine Cables"), according to which a very large proportion of the cables laid in shallow waters are destroyed either by abrasion against rocks or gravel, or by ships' anchors, in less than ten years. We also know that both the Atlantic cables have been more than once ruptured, and have remained so for months at a time. Our experience of the longevity of cables laid in the tropics and Eastern seas is almost limited to the first Red Sea cable, the Persian Gulf cable (one of the best cables ever constructed), the Cuba, and some short cables laid in India. From this experience we learn that in hot climates, and especially in shallow water, the wire guards of cables suffer severely from the heat, from abrasion against coral and other rocks, ships' anchors, and that the core is attacked by Teredo worm when exposed.

Cables laid in very deep water are pretty safe from ordinary accidents, but they must have shore ends, and when damaged cannot be repaired at any time without considerable expenditure of time and money, and not at all in bad weather, which, in tropical seas, means during the five or six months of the rainy season.

The popular belief that signals are always transmitted with greater speed through cables than land lines, is due to ignorance of the conditions under which this becomes possible. It can only happen when the length to be signalled through is so great as to require more repetitions on the land line than by cable.

On a land line the electric current discharges itself instantaneously, therefore the limit to speed is the rate with which the signalling instruments can be manipulated; under certain arrangements it is quite possible to attain a speed of 60 words per minute, but in practice the rate rarely exceeds 25 to 35 words a minute. On a cable the case is quite different; the conductors being enclosed in a dielectric, in contact with the earth or water, the cable cannot discharge itself instantly. In fact, electric phenomena occur which prevent the rapid transmission of signals, and more than 10 or 12 words per minute cannot be transmitted with any pretension to accuracy.

The limit over which telegrams are transmitted automatically in fair weather, is about 800 miles in Europe, about 1,000 miles in America, and somewhat more in India. During the continuance of great atmospheric disturbance—such as the commencement and breaking up of the rainy season—it is difficult to transmit signals without repetition, even 500 miles.

No limit has yet been found to the length of cable through which it is possible to transmit a signal; but as the signalling decreases in speed as the length of cable increases, about 1,200 miles is considered the most convenient distance for stations to be apart. At this distance 12 words per minute is a fair rate of signalling on a cable of large capacity.

It is therefore obvious that, *cæteris paribus*, a cable is inferior to a land line for distances of less than 2,000 miles. We have already stated that cables are at a disadvantage in shoal waters. Land lines on a sea coast, especially in the tropics, are, on the other hand, also at great disadvantage; the hot moist air carries off a great deal of the current and rapidly corrodes the wires. They are also peculiarly

liable to interruption from cyclones and severe winter weather. Lines through dense forests, especially in the tropics, are difficult to maintain. Lines that cross broad rivers are at great disadvantage. As a cable costs at least three times as much as a land line, it is worked to best advantage when it shortens distance—such as when it is laid across a deep bay or a strait, or an arm of the sea.

A well-erected and well-insulated land line through an open country, along a good line of communication, especially if that line be a railway, is as near perfection as can be, and where these conditions rule, a land line is incomparably preferable to the very best cable that can be laid.

The Red Sea cable will be laid from Suez to Bombay in very deep water, by a route far shorter than would be possible for a land line, and should, if secured against abrasion on the coral rocks near Mocha, be a success; but a cable laid between Bombay and Galle must follow the general run of the coast, and be actually longer than the land line. It will be in shoal water, amongst rocks, and for many months in each year will be exposed on a lee-shore to the full force of the south-west monsoon; the landing, too, at Galle, will be exceedingly difficult. A cable, laid from Galle to Singapore will also meet with great difficulties; it cannot be laid direct to Acheen Head, and all through the Straits of Malacca, 400 miles, it will be exposed to all the dangers inseparable from shoal water of only 20 or 30 fathoms. Ships beating through the Straits, anchor anywhere most convenient to themselves, a certain source of injury to cables laid in these waters.

What the public really requires is, not a cable between Bombay and Galle, but the adoption of that scheme which combines in one homogeneous whole all the strong points of each of these projects. What they should demand is, that line or combination of lines which will give them the best results at the lowest possible cost. Now a glance at a good map of Asia shows that there is no necessity to go to Galle* at all; the most direct mode of reaching Singapore from Bombay is through Madras; and if it be remembered that Bombay and Madras, which will very shortly be united by railway, are only 760 miles apart—that is to say, within easy direct electric communication—it is evident that a telegraph starting from Madras, starts with a great initial advantage.

The facilities for laying a cable from Madras are also far better than those presented by Galle. At Galle, the harbor is confined, the entrance narrow, and the surf even in the calmest weather breaks incessantly over its rocky coast, and nowhere round the coast, until the neighborhood of Trincomalle is reached, exist bays or indentations suitable for the landing of a cable.

From Madras, on the contrary, a cable would be laid on a sandy bottom, and start in the direction of the point to be reached, and if the site for landing be judiciously chosen, such as where a bar is forming across a small river mouth, the cable would soon bury itself and become practically indestructible.

The scheme that we should like to see projected and well supported by one large company is that recommended by Colonel Robinson, the Director-General of Indian Telegraphs, viz., lay a cable from Madras to the mouth of the Pak-Chan river, the southern extremity of the Tenaserim Provinces, touching at Port Blair, whence a branch should be laid to Rangoon, and possibly to Acheen Head; a short land line of 70 miles across the isthmus at Kra would connect this cable with another to be laid across the Gulf of Siam to Cambodia Point of Saigon. From Tayoung, the east terminus of this short land line, a branch land line should be carried up the eastern coast of Siam to Bangkok, only 270 miles distant. Singapore should be connected either by a land line along the east coast from Tayoung, or with Cambodia Point by cable.

This scheme presents, apparently, the strongest, cheapest, and most direct main line which can be laid between London and Hong Kong, with branches to Galle, Rangoon, Bangkok, and Singapore, the latter capable of extension to Australia. It is evident that this line, besides being stronger, would cost so much less, that it could afford to transmit telegrams at much lower cost, and with greater speed, than the Galle-Singapore cable; and hence, whether the Govern-

* Galle seems to have been selected because it is the southernmost point of India, and the grand junction station for the several lines of steamers plying on the Eastern seas, and this, though ample reason for making it a branch, is not sufficient for putting it on the main line of communication.

ment of India carries out its proposition to give substantial aid (in the way of a cable across the Bay of Bengal) to any scheme that shall give evidence of stability, or not, we trust ere long to see a company, or combination of companies, started with the object of undertaking either the extensions beyond Port Blair or the Pak-Chan river, or of the whole scheme in its entirety.

WIND PRESSURE ON BRIDGES AND ROOFS.

From "The Engineer."

Recognizing, as we have always done, and advocating as we always do, the advantages of a sound knowledge of theory, and an accurate appreciation of its value, it must, nevertheless, be admitted that there are certain instances in which it becomes absolutely impossible to reduce its dictates to practice. It is not merely the labor that it imposes on its votaries in some particular cases that acts as a deterrent, but also the uncertainty as to the result that is ultimately arrived at through its instrumentality. There are some theoretical calculations which, with all the respect we have for their intrinsic merit, do unfortunately terminate in "vanity and vexation of spirit." In such examples practice and experience come most opportunely to the rescue, and solve the problem that by reason of its complexity would otherwise remain, to all intents and purposes, indeterminate and unproven. Digressing for the moment, the pertinent question presents itself, how is it that some engineers, by an almost natural aptitude—it might almost be termed instinct—do perceive at a mere glance the fitness of any proposed design for its required duty? They make no elaborate calculations respecting the dimensions of the several parts, they do not care to inquire whether this member is a strut and that a tie, whether there are 5 tons or 6 tons per sq. in. upon the metal, but state at once, without the slightest hesitation, that it will carry such and such a load safely. Whence is this practical discernment derived? In our opinion it is due to natural ability and genius.

In the designing of bridges and the proportioning of their several parts, the conditions attending the development of the strains are usually determined upon the separate assumptions of a fixed and a variable, or, as it is also termed, a dead and a live load. Two tables of the results should always be compiled—the one giving the maximum strains under the hypothesis of the load being uniform and stationary, and the other, those arising from the action of the moving load in the several positions it can practically occupy. Should the latter calculation be omitted, as it sometimes is, it is impossible to arrive at the opposite duties which may be required of any particular member of the structure, and any attempt at scientific and economical counterbracing becomes impossible. The experience derived from the construction and erection of the Britannia Bridge tends to demonstrate that the pressure of the wind, so far as structures of that class are concerned, produces little or no effect upon their general equilibrium. Not that it is to be disregarded; but it cannot be considered as materially increasing the assumed load, either fixed or variable, which enters into the calculation of the necessary sectional area of metal proper under the circumstances. The resistance to wind pressure is obtained not so much by strengthening, but by stiffening a bridge or roof. Insistent weight and rigidity are the best counteracting elements. The type selected for a bridge considerably modifies the nature and intensity of the force of the wind. A girder with an open or lattice web will be but little affected by the most violent storm, at whatever elevation it may be placed; but if a solid-sided or plate girder be in the same situation there will be a large amount of lateral stress induced upon one or other, and perhaps upon both of its sides simultaneously. Taking one of the Menai tubes, for instance; if we imagine a strong wind blowing upon one of its sides, it may be regarded theoretically as equivalent to a temporary weight or pressure acting uniformly, or what amounts to the same, uniformly distributed over its whole length. Under these conditions, it is obvious that there is a close analogy between the resulting strain

and that induced upon the centre of a girder by a horizontal load. The maximum bending moment will be evidently proportional to the pressure of the wind upon the unit of surface multiplied by the square of the span, the resistance being directly as the *vis inertiæ* of the bridge and its own rigidity. The maximum pressure upon the Britannia bridge was found to be only half a ton per sq. in. This is also apparent from the fact that although the wind may not affect a bridge throughout all its parts with the same degree of force, yet its action is never so purely local as to be confined to one particular section or short length. The tendency of a wind pressure on the side of the Britannia tube is not to shear the web in any particular vertical plane, but to sweep the whole structure bodily into the straits. In this instance any more stiffening applied solely to the side would be of little or no use. It is the whole bridge that must be rendered rigid. The two tubes are assailed *en masse;* their only safety is in a close and intimate union, combining their individual resistances so as to act as one rigid piece of construction. It was not at first intended to place the two tubes in this relation with one another, but the advantage of so doing was speedily recognized and acted upon.

A roof is differently affected by the wind to a bridge. In this respect it must be confessed the modern light iron trusses are comparatively at a disadvantage with the older, heavier type of timber constructions, which, although the absolute covering of slates, tiles, or of whatever nature it might be, was sometimes blown off, yet remained firm and unshaken. The pressure of the wind may affect a roof in three ways. It may affect it from without or from above, from within or underneath, and it may also affect it locally, or confine its action to one-half or even one-quarter of the entire principal. Let us take as an example a curved trussed roof of the type that is particularly applicable to stations, engineering workshops, and manufacturing sheds, and proceed to determine in what manner allowance is to be made for the pressure of the wind, which has been observed in this country to obtain a maximum value of 55 lbs. to the square foot. First for the external action. The roof being curved, it is clear that even on the supposition that the angle of incidence of the wind is constant, the angle of actual pressure will vary from the crown to the springing. But in reality the wind rarely blows in a storm at a constant angle. On the contrary, it blows at all angles from the vertical to the horizontal, and, in consequence, will be sometimes vertical, sometimes normal, and sometimes tangential to the surface of the roof. The assumption that the pressure of the wind may be considered as a vertical force, and that therefore so many pounds per sq. ft. may be added to the weights already estimated to rest upon the structure, is erroneous, for in that case it would affect each half of the roof equally and simultaneously. Under these circumstances, therefore, it would be equivalent to simply increasing the uniform load, and regarding the principal as subjected only to a load of that character, which is incorrect. It is true that a roof is not acted upon by a movable load in the same manner in which a bridge is affected; but it is subject to a variable load, which, as it has been already stated, may cover the half or the quarter of one side. At whatever angle the wind might be assumed to act, it is scarcely possible that its influence could be spread over a less space than one-quarter of the half, or one side of the roof. Sir W. Fairbairn observes that, in reference to roofs, "every pair of principals composing such structures should be self-supporting, that is, should have sufficient stiffness within itself to sustain a load of 40 lbs. per sq. ft." This load is considered to be a uniform load. How, then, is the variable pressure of the wind to be taken into account? In the first place, it must be borne in mind that 40 lbs. per sq. ft. is considerably in excess of the actual weight of the covering and the roof itself, and includes a certain allowance for wind pressure. The largest slates weigh bnt a trifle over 8½ lbs. per sq. ft., so that the margin that is left can be well imagined, more especially as in the examples to which allusion is made a much lighter covering than slates is usually adopted. In addition, there is also the additional guarantee of security afforded by the ratio of the working or safe load to the ultimate strength of the material. Instead, therefore, of treating this weight of 40 lbs. per sq. ft., or whatever other unit, not less than this, that may be adopted, as a uniform load, it

it should be treated as both a uniform and a variable load. In other words, the effect of each successive portion of this or a greater weight situated at each apex should be carefully ascertained by a diagram of strains, and the results tabulated. The one will give the strains due to a uniform load, and the other that due to a partial one. The latter will indicate the local action of any particular weight or weights, and will point out how, under certain conditions, particular parts of the truss which are under either compression or tension, when subjected to a uniform load, will undergo strains of an opposite character when that load is regarded as only partially distributed. Having, therefore, ascertained the conditions of strains due to a uniform load upon the various parts of the roof, and tabulated the results, let another table be compiled showing the effects of a partial loading, and then the necessary counterbracing can be introduced. But there yet remains a very important element of stiffness to be added, namely, the wind ties. These are required, not only to assist in resisting the external violence of a storm or hurricane, but also to prevent the pressure from underneath literally "blowing up" the roof. If the wind once gets "well under" a roof nothing but the fact that the greatest care and precaution have been bestowed upon its bracing will prevent it being carried away. We have known an instance in which, from want of attention to the proper tying together of the principals, the whole roof was lifted bodily off the side walls and landed in an adjoining field. The storm continuing, the walls gave way also, and the cost of restoring matters to their original condition amounted to £1,500. The fault of most wind ties is that they are not carried down low enough. There is no necessity for tying the principals together by wind ties. They are already amply secured by the purlins and the whole covering in general. The point to be aimed at is to tie them back upon the respective supports, so that the principals could not be lifted without taking the foundations with them. Basing our estimate upon the data already assumed for the maximum pressure of the wind, the upward force would be equal to 55 lbs. per sq. ft., and would consequently lift nearly that weight vertically. Unless, therefore, the insistent weight of the roof per sq. ft. were greater than this amount, it would at any rate be able to be seriously shaken by a force of that intensity. The aid, therefore, of some further mode of securing the principals is evident, as roofs of moderate, and even large spans, do not equal in weight the figures arrived at by observation for the maximum wind pressure. The strength required to be given to a roof will be most accurately calculated by a due attention to those principles which theory dictates, and practice sanctions; but its rigidity and stiffness will be best provided for by experience, combined with a little of that "artifice" which every thoroughly qualified engineer knows when and how to employ.

THE *Athenæum* records the following important experiment made by Sir Thomas Maclear: "I built (he says) two pillars of solid masonry, and sheltered them at a locality on the line. Each carried a micrometer microscope. With these I compared the relation between the expansion of the standard iron bar and the indications of the two thermometers with oblong bulbs sunk in holes in the bar and surrounded with oil, and observed in the accidental temperature of the atmosphere, at short intervals, throughout 24 hours, night and day. The expansion of the bar in ascending temperatures, and contraction in descending temperatures, were about 2 hours behind the indications of the thermometer. To this circumstance are owing in part the rough results of comparisons in the field between the standard iron bar and the compensation-bars.

R. VON BRAUSE states that he has discovered coal of very good quality in the Santa Cartharina, near Ararangua. The seam which crops out has been explored for a distance of some 30 miles, and found to be an average thickness of 1 metre. This coal has been thoroughly tested and analyzed by Dr. Netto, of Rio de Janeiro, and is interesting as one of the very few instances of a true coal occurring in a recent geological formation, although in the United States and in Hanover (on the very borders of the Netherlands) two or three such occurrences are on record. The coal here alluded to is an excellent quality of gas coal.

REPORT ON BOILER EXPLOSIONS.*

From "The American Railway Times."

Questions.

1. Please give me as minutely as possible, all the particulars connected with any boiler explosion with which you may be familiar, whether on your road or any other? The shape of boiler, thickness of iron or steel, diameter, and state as near as you can learn, what pressure of steam was carried at the time, and what was the highest pressure the boiler was ever subject to? Also whether there appeared to have been any defect in material or construction of the boiler; whether it had been weakened by corrosion, either inside or out; or was at any point "furrowed;" whether weakened by the gradual breaking of stay-bolts and bars? If so, how many were broken previous to the explosion; and in your opinion, what part of the boiler first gave way, and what was the cause of the explosion?

2. In your opinion, is the accumulation of mud or scale liable to produce an explosion, by the sheets becoming overheated and weakened from that cause?

3. Is the admission of feed-water at or near the fire-box, or where the water will come in immediate contact with the hot sheets, thereby producing a sudden, frequent, and unequal contraction, liable to weaken the boiler at such points?

4. Does the frequent variation of the pressure, and the frequent expanding and contracting of the sheets, produce crystallization, and, in your opinion, weaken the boiler?

5. In your opinion, have the minerals and impurities contained in water an injurious effect on the metal, thereby weakening it to such an extent as to be liable to explode?

6. In your opinion, as far as your observation goes, "What is the cause of boiler explosions?" Is it in all cases from an over-pressure that the boiler is not able to stand? From its being weakened by its long-continued use? Corrosion? Giving away of stay-bolts? Faulty construction? Bad proportion of boiler, etc.? Or do boilers sometimes explode, where no satisfactory explanation can be given as to the cause?

Report.

GENTLEMEN,—The subject of boiler explosions has attracted the attention of almost every one connected with the management of steam boilers and engines. Theories respecting their causes are innumerable, and multiply with every disaster of the kind. It would be impossible to state the various ideas advanced by mechanical engineers, practical men, and especially the unacquainted, who are unsparing in their advice. As a committee appointed to investigate this subject, we will endeavor to trace the causes to such defects as have presented themselves in past experience, and in conditions liable to occur in daily practice.

It is true, explosions have occurred where no definite causes have been given; but these are rare, and would, when thoroughly investigated, be reduced to a very small percentage of the whole number of disasters.

The theory of the decomposition of water seems to be a fallacy, as gases so generated would be harmless in this condition without the presence of air to combine with, and is generally discarded. The generation of nitro-glycerine or gunpowder, based on the fact that so many tons of water contain so many atoms of its chemical constituents, seems to have but little weight. Experimental philosophy, however, has demonstrated certain conditions which may occur. "The Projectile Theory," advocated by Colburn, Clark, Tindel, and many other eminent engineers and scientists, attracts attention. For instance, water, in its normal state, holds a large quantity of air in solution, which after boiling for a time, will be expelled, and liquid of a cohesive quality produced. In this condition the temperature can be raised high above the boiling point before ebullition takes place. On rupturing this cohesion, ebullition partakes the nature of explosion. It is conceivable that a great amount of heat may thus accumulate in a boiler, and lie dormant around the heating surface. The water in this condition prevents its rising to the surface, until some mechanical action, such as opening the throttle or disturbing the safety-valve, imparts motion to it, and steam of explo-

* Before the American Railway Master Mechanics' Association.

sive force is set free. Although a theory, experiments have demonstrated that such can be the condition of water at high temperature, and the liberation of such heat takes place with extraordinary violence.

Explosions which have occurred at the instant of starting the machinery, or producing commotion in a boiler after remaining quiet for a while, tends to substantiate this.

The following table shows an exceedingly rapid increase of pressure as the temperature rises :

Deg. Fahr.	Pressure in lbs.
234 =	7
248 =	15
263 =	22
275 =	30
302 =	45
320 =	75
338 =	105
356 =	135
374 =	180
392 =	225
410 =	285
428 =	345
450 =	430

When 15 lbs. pressure is obtained at 248 deg. Fahr., it takes about 2 deg. additional heat for every pound of additional pressure; when at 180 lbs., 374 deg. Every 2 deg. above this will give about 5 lbs. additional pressure, and at still higher temperature this effect is still doubled, and is thus ten times greater than at low temperatures, showing the danger of excessive heat in furnaces.

The theory of the "Spheroidal" condition of water has also attracted attention. This can be illustrated by pouring a small quantity of water on heated plates, having a temperature above that of high pressure steam. Such overheated plates repel the water thrown upon them, which assumes the spheroidal state, the excessive heat interposing a film of steam, until their temperatures are sufficiently reduced, when direct contact will take place and rapid evaporation follow. This can be daily observed in forges and rolling mills, where water is let upon surfaces of iron heated to redness, causing detonations like the firing of guns. Surfaces of considerable extent may be thus exposed in a boiler, and should the conditions be the same, a danger of explosion exists. The speedy unequal contraction of the boiler plates subjected to such a state, may produce fractures, or weaken them to such an extent as to cause serious apprehensions. This condition can take place in two ways: 1st, by the injection of cold water, which would rush on the plates absorbing the extra heat, causing a dangerous contraction of a whole sheet already in a weakened condition; 2d, by irregular firing and other means, large portions of scale liberated from the heating surfaces in a boiler, having an abundance of water and all appliances for indicating its state in perfect order. The scale adhering to the surface, and being a bad conductor of heat, we need not be surprised to find sheets literally destroyed by continuous heating and cooling. The use of the numerous anti-incrustation powders, or by mechanical impulse, may detach portions of it, exposing a large surface heated to redness to the action of the water, and cause explosions.

The Committee of the Franklin Institute found that clean iron plates vaporized drops of water fastest when heated to 344 deg. Fahr. The development of repulsive force was so rapid above this temperature, that drops which required a second of time to disappear at the temperature of maximum vaporization, required 152 seconds when heated to 395 deg. Fahr. One ounce of water which was introduced into an iron bowl three-sixteenths thick, at a temperature of 546 deg. Fahr., was vaporized in fifteen seconds, while at a temperature of 507 deg. Fahr., the most rapid evaporation was thirteen seconds. The cooling effect of metal is here exemplified by the increased rapidity of evaporation, which, at a reduced temperature of 38 deg., is effected in thirteen instead of fifteen seconds. This does not hold good in all cases, as an increased quantity of water, say from one-eighth of an ounce to two ounces, thrown on heated plates, raised its temperature of evaporation from 460 deg. to 600 deg. Fahr. Thus clearly showing that the time required for the generation of explosive steam under these circumstances is attended with danger, and it is doubtful whether the ordinary safety-valves may not be wholly inadequate for its escape.

Corrosion.

Corrosion, though we may retard its progress to some extent, will take place in and about the best protected boilers; rust being an oxide produced by the action

of moisture and atmospheric air on surfaces of iron exposed to it.

After testing a boiler to nearly double its requirements by hydrostatic or steam pressure, minute leaks will break out, through various causes; hard firing and rapid cooling will produce the same. The usual coverings of boilers prevent the immediate discovery of such damage, and not until the harm is done are means used to check it. Leaks, unless caused by defects in the body of sheets, are found along the laps of seams, through defective rivets, and around the braces and angle irons. Over-pressure and unequal expansion and contraction are the causes; the latter shows the most ruinous effects by "furrowing" the sheets along the laps, and fracturing them, when braces with insufficient bearings are attached. Corrosion takes place mostly on the under sides of boilers, and sheets are often found of less than $\frac{1}{16}$ in. thick required to stand 130 lbs. working, and eventually bursting with pressure. The legs of fire-boxes and bottoms of smoke arches are also liable to suffer from this cause, as the leaks from flues and seams and the presence of ashes produce a state so favorable. Internal corrosion progresses slowly; this may be accounted for by the comparative absence of air, and chemical combinations, which, to the present time, have not been sufficiently investigated. A singular phenomenon presents itself in this connection: recesses are found, varying in size from $\frac{1}{4}$ to $\frac{3}{4}$ in. in diameter, and extending nearly through the sheet, singly and sometimes in groups. They are generally found on the bottoms and lower sides of boiler shells, in places covered with sediment; though never sufficiently explained, it may be due to the concentration of saline deposits of certain kinds of water, which adhere to the iron and gradually cause corrosion.

Deposit of Sediment.

Scale and other solid matter accumulating on the heating surfaces of a boiler will prove detrimental in time. The furnace sheets subjected to the intense heat are unable to transmit it to the water wherever such deposits interfere. The structure of the iron is by repeated heatings soon destroyed. The first indication of such a state, is the bulging of sheets, causing cracks; and if occurring on large surfaces not properly stayed, a liability of suddenly giving away exists. The lower portion of fire-boxes are especially liable to this action, and sheets are often found bulged between stay bolts, and in many cases the threads partly stripped. No other explanation is given, as over-pressure would show its effects on all stay bolted surfaces alike. Deposit will accumulate rapidly in the front ends of locomotive boilers, causing flues to leak, and finally produce internal corrosion. Generally the first course back of smoke arch will be affected by this before any other part of the boiler, and explosions have occurred from the gradual wasting and consequently weakening of the sheets.

Explosions from Defective Steam Gauges and Safety Valves.

Safety valves of proper proportion, and in good working order, are considered sufficient for the escape of steam generated under ordinary circumstances. But there are certain conditions which may take place when steam is generated so rapidly, that they are useless even at ten times their usual area, and would not relieve the pressure in time to prevent explosions. In many instances the valves adhere to their seats, where they have not been used for a time, and in this condition are of no avail. We frequently hear of explosions where this is one of the given causes. Safety-valves will not prevent explosions where boilers are weakened by corrosion, old age, and inferior material. If properly constructed and taken care of, they may be considered a safety as regards over-pressure to a certain limit. The same may be said of steam gauges, which are a convenient and ornamental indicator, but are useless without care. At times the connection pipes become stopped by sediment, and it is not an uncommon occurrence to find them varying from 10 to 40 lbs. This may account for explosions which have taken place when the gauge was said to have shown a certain pressure, and yet was far above that actually indicated. Safety-valves and steam gauges are indispensable in all kinds of steam engineering, but, like many other attachments to locomotive boilers, are useless unless in perfect order.

Explosion from Deficiency of Water.

This is mentioned as a source of danger,

and may well apply to boilers where large shells or flues are thus exposed, as in stationary or marine boilers. In a locomotive boiler, the crown sheet would be the first affected, and immediately after this the tubes, which would readily give warning. A properly stayed crown sheet and fire-box are the strongest part of a boiler when kept in repair, and engineers are generally aware of the condition of water. At times they run short, but always prefer cooling down before burning a set of flues. The danger exists principally in the injection of water after the sheets become red hot, which may bring about the spheroidal state or cause fractures by contraction. Reliable pumps carefully attended to are the only safeguards. Water should be admitted in a part remote from the heating surface, so as not to cause contraction by the rapid absorption of heat.

Explosions from Defective Construction.

Faulty design and bad construction rank next as sources of danger. As a decided and varied opinion exists as to the proper and best shape of boilers, and different plans have apparently done equally well, we will only point out the one almost universally adopted. Over the crown sheet the shell is raised from 4 to 12 in. This part is usually connected to the shell by two sheets on top and part of sides, and fire-box by throat sheet. This and the top sheets have caused serious trouble on account of their shape and position, and are more than any other affected by the action of expansion and contraction. The usual absence of scale may be taken as an evidence, and the leaks along the seam, and often fractures of the surface of sheets, which gradually lengthen. Equally dangerous is the raised part on wagon top; this part forming the half of an ellipse, has a tendency to assume the shape of a circle, and if insufficiently braced and stay bolted, can never retain its shape, so essential to its safety. Crown bars too weak for the resistance required of them are often met with, and in many cases very inferior material is used. By making the bars strong, and tying the dome and shell to them, thereby producing a counter strain, the danger from this cause is avoided, and the boiler must retain its original shape. Explosions have occurred from defective and improperly shaped crown bars. The usual manner of thimbling between the crown sheet and bars is a matter of importance. We frequently find thimbles from $2\frac{1}{2}$ to 3 in. in diameter and $\frac{5}{8}$ of an inch thick, bringing the bars too near the sheet, and is more liable to collect scale, which is difficult to remove by the ordinary means. Thimbles of the above dimensions form too great a body of iron, causing the sheet at the rivet to crack in various directions, weakening and destroying the material, which is liable to give away without warning. The proper size of stay bolts and the distance between them is a simple calculation, but the reckless mode of laying them out, that in many cases the inside and outside holes do not coincide in the line of their longitudinal strain by inches, is often met with. Stay bolts, especially the upper ones, are liable to give out where proper braces above the crown sheet are omitted. If one or two give out the rest will soon follow, by reason of an increased strain on the remainder; and cases where 2, 3 and 4 rows have given out is no rare occurrence. The sounding of stay bolts in the usual way cannot always be relied upon, as broken ones will gather scale between the ends, and sounding can only be intrusted to the best of experts. Frequent explosions have occurred from the gradual breaking and suddenly giving away of stay bolts, and, being hidden from sight, some means should be devised by which they may be detected. As a remedy for this, we would suggest the adoption of hollow bolts, with holes drilled through them about $\frac{1}{4}$ of an inch or less in diameter. This would increase the cost to some extent, but the advantage would be, in case one should break either partially or totally, it would soon make itself known, by the discharge of steam and water through it giving due warning, and by replacing with another would relieve the balance from extra strain. Plugging the bolts on the inside when first put in would prevent (in case of a broken one) the discharge of steam in fire-box forcing it to the outside, which could be easily plugged, and prevent delays until replaced. This plan is adopted by many of the Continental railways, proving a success, and in many instances preventing explosions. The frequent variation of pressure together with the tensile strain upon such parts of

the boiler as are not perfectly sound and properly stayed, is one of the most powerful agents of destruction. The laps of seams have with few exceptions been held together parallel with the surfaces of the sheet. Although a universal practice, we will compare it with a second one coming into favor, and based on experiments made with the two kinds. It has been demonstrated, that a seam subjected to a severe strain assumes a shape in which the centre line of one sheet tends to strike the centre line of the other, forcing the edges out of their parallel position. Trials seem to prove the latter the rational shape, and enduring the greatest strain. This plan of shaping the sheets at the laps has a tendency to retain their natural position, and the difference in pressure would not cause them to change their shape and weaken them by the constant working at their connections.

We will briefly investigate the manner and manipulation of building boilers, the common abuses practised so generally: 1st. The loose manner in which the holes are laid out, and as a consequence the use of drifts, to make a bad job worse. Through the ignorance or neglect of workmen, the holes do not come right by sometimes half their diameter; are drifted until the sheet is fractured and the material destroyed. This habit cannot be too much reprehended, and the use of drifts, although considered indispensable by many good boiler makers, is productive of more mischief than good. 2d. The flanging of sheets has often destroyed the best material before the work was put together, especially turning flanges too short, causing cracks and flaws. Locomotive boilers working with 130 lbs. pressure are like magazines of powder, and we have enlarged on the details with a view of impressing its defects on the minds of all concerned. Too much care cannot be taken in their construction and management, and no man should be intrusted with it that shows a disposition to recklessness or neglect.

But in many cases, well-constructed boilers are injured by appliances of either convenience or luxury, which tend to shorten its life and increase the cost of repairs without giving any equivalent. Considering its purpose and the strength required, all unnecessary appendages should be avoided as detrimental to its existence. An opening, however small and well stopped, is an invitation for leaks. Good covering for the purpose of preventing radiation is necessary, but we call attention to the prevailing rage which hides dangerous defects and makes the vital part of a locomotive a camel's back for every conceivable contrivance. The following is the percentage of explosions assigned to different causes as received in answer to the foregoing questions:

To faulty design, bad construction, poor material, and carrying more pressure than boilers under such circumstances are able to bear	9
To broken stay bolts	3
To corrosion	3
Unaccounted for	2

The latter may be attributed to defective steam gauges and safety-valves, or by accepting the theories mentioned. The reported cases may be relied upon as being correct, and, although limited, must furnish a basis for conclusions until a greater number, or more detailed descriptions are obtained. It appears to be a positive fact that by far the greater number of explosions can be traced to rational causes, and speculations with its theories and unfailing preventives can only be exercised in exceptional cases. Locomotive building, though it has long ceased to be considered an art, requires the utmost attention in respect to general design, construction, and the selection of material. The locomotive from the date the first engine was placed on the track by the Father of Railways has a brighter record than any other branch of Mechanical Engineering. An extraordinary succession of improvements marks its course, and it is more to be regretted that explosions take place where supernatural causes are given, though it is universally admitted that steam is a controllable agent to all intents and purposes.

All of which is respectfully submitted.

J. Losey,
Wm. Hellar, } *Committee.*

A plan for uniform railroad gauge is under consideration by railroad men and members of Congress. Five-sixths of the roads already have the same gauge—4 ft. 8½ in. The expense of changing will not exceed $500 a mile.

GLYCERINE—ITS USES AND ABUSES.

By Prof. C. A. JOY.

From "The Journal of Applied Chemistry."

A few years ago glycerine was only known to scientific men; but now it is so extensively employed as to be familiar to everybody. Scientifically, it appears to be a species of alcohol; popularly, it is the sweet principle of oil. For many years it was thrown away, but now it is saved and converted to numerous uses. Few chemical compounds have increased so rapidly in public estimation as this. From being regarded as a waste product, it has grown to be as valuable as its former proud associates, and appears destined to take a most prominent place in the arts. It exists in oils and fats, and as it was not essential in the process of making soap and candles, and no use could be invented for it, it was either destroyed or allowed to flow away. We are sorry to say that at the present time a great quantity flows down the throats of a long-suffering and much deceived wine-drinking public, instead of passing through the spout of the soap and candle maker. We do not propose to go into a long account of the way glycerine is manufactured, because any one curious upon that point can easily turn to an encyclopædia for information, but we know that it will interest our readers to learn something of the recent applications of this substance.

Housekeepers will be glad to know that if tubs and pails are saturated with glycerine, they will not shrink and dry up, the hoops will not fall off, and there will be no necessity of keeping these articles soaked. Butter tubs keep fresh and sweet, and can be used a second time. Leather treated with it also remains moist, and is not liable to crack and break.

For the extraction of perfume from rose leaves, from scented woods, from bark, from gums, there appears to be nothing better than glycerine, and this use of it is constantly on the increase, as the most delicate odors are perfectly preserved in it.

A soft soap, in which glycerine enters as a constituent, is highly prized in cold weather, when the hands become chapped, and can be used for washing in hard water.

For wounds and sores, and bites of venomous insects, glycerine is found to be a most valuable substance, as it either prevents the mortification of the parts, or it can be used to carry the remedies to counteract the effects of poison.

To preserve animal substances from decay, glycerine is now substituted for alcohol, in collections of Natural History, and it is employed to keep many articles of food from undergoing decomposition.

As it requires an intense cold to freeze it, even when mixed with its own bulk of water, it is largely employed to fill the wet gas metres.

Some kinds of candy, chocolate, confectionery, and fruit, which are preserved in tin foil, are kept moist by a small quantity of glycerine.

Delicate chronometers, clocks, and watches are lubricated with it. Copying-paper and wall-paper, for taking fancy colors, are also kept moist by a small amount of glycerine used in this manufacture.

In pharmacy, for the preservation of pills, to mix with many substances, in compounding prescriptions, and in more ways than can easily be remembered, glycerine now plays an important part.

In the arts it finds its way as the best wash for the interior of moulds in the casting of plaster figures, to prevent the gypsum from adhering to the sides of the mould.

In dyeing with some of our beautiful organic colors, glycerine is extensively employed with the best effect.

In chemistry it is used to prevent the precipitation of the heavy metals by the alkalies, and is thus a re-agent in analysis.

For making an extract of malt to improve or spoil, as the case may be, the beer manufactured in the usual way, glycerine has recently attracted a great deal of attention, and been the object of extensive speculations, if not of impositions upon the public.

In the preparation of *liqeurs* it has been found to be admirably adapted for preserving the characteristic flavors of these compounds, and it has consequently be-

come the great favorite of this class of manufacturers.

As glycerine is a remarkably stable compound, it is adapted to the preservation of wines, and this legitimate use of it has suggested to the adulterators of liquors an extensive fraud upon the community. Vast quantities of glycerine are annually manufactured, and as the known uses of it will not account for the consumption of more than a small fraction of what is made, it is difficult to explain the disappearance of the remainder. What takes place in the dark champagne vaults and cool subterranean wine cellars, evidently will not bear the light of day, and hence we neither see nor hear what becomes of the great stream of glycerine that is known to flow into them. Fortunately, it is not a poisonous substance, and its use for adulteration is consequently attended with less detriment to our stomachs than to our pockets. Whether the coming man will drink pure glycerine instead of wine, must be left for future consideration.

It has been discovered that glycerine can be fermented into alcohol with chalk and cheese, and it may be possible hereafter to manufacture alcohol in this way. The discovery is an important one,and may suggest some improved and cheap method for obtaining alcohol and acetic acid.

The last use of glycerine that we shall mention is, perhaps, the most important of all—its extensive application in the manufacture of nitro-glycerine. This explosive oil is made by treating glycerine with nitric and sulphuric acids in a peculiar manner. It has been known to chemists for some years, but it is only recently that a Swedish engineer has had the hardihood to propose it as a substitute for blasting powder. Its introduction has been attended with fatal consequences to many of the pioneers and earliest adventurers who have experimented upon its properties, but it is making rapid progress to public favor, and, in a few years, will, beyond all question, displace the old-fashioned blasting powder, and reign in its stead. By mixing the oil with sand, a solid explosive agent has been made, which is called dynamite. This is much less dangerous than the oil, and nearly as destructive in its effects, as it contains seventy-six per cent. of nitro-glycerine. A patent percussion-cap and safety-fuse is required for the explosion of dynamite, and, according to all accounts, it appears to be less dangerous than gunpowder.

The glycerine, which has come into notice within a few years, has become an article of great importance, and as its conquests are daily extending, we may expect to become very familiar with it, and to learn to appreciate it as another valuable contribution of chemical science to the ordinary wants of man.

SILT EMBANKMENTS.

From "Engineering."

Few of our readers are ignorant of the construction of the beaver dam, in which the economic employment of natural forces is adopted by the beaver, for the purpose of damming up the streams of rivers—an operation which,when undertaken by man, generally necessitates the employment of a vast number of laborers, much machinery, and great expense. The cost of such works in India has always been considerable, whilst there also exists a need of them far surpassing what is felt in any other country in the world. The monsoon seasons, during which part of the year alone does any great quantity of rain fall, invariably flood the rivers of India, their waters being carried away to the sea, leaving the parched land, during the dry season, without that supply of moisture which required only the work of man to store up during its abundance, against the time when its need is most felt. At the foot of all mountain ranges, whence most of the rivers derive their source, there exist many valleys which only require bunding across on one side in order to convert them into gigantic reservoirs, and which, being filled during the rains, would retain a sufficient supply of water to the rivers which formerly drained their catchment basins to maintain in them a running stream for the greater portion, if not for the whole, of the dry season, and which, by suitable arrangements, might be utilized for irrigating the adjoining lands, thus materially contributing to an increase of

the food supply of the country, at the same time that, by preventing floods at another portion of the year, the land would be protected from injury by inundations. The expense of such works has naturally led to their limited construction, whilst many parts of India are in urgent need of them. There has now, however, been in progress for nearly 18 months the experimental construction of an embankment by the "silting" process across the head waters of the Bhowany River, below the junction of the Porty and Avalanche nullahs, on the line of road which is being formed to connect the Neilgherry and Koondah hill ranges in the Madras Presidency; the result of which will not only shorten the distance by about 4 miles, but it will also inclose a vast reservoir, to be called Lake St. Lawrence, of capacity sufficient to supply irrigation to some 2,000 acres of land. This system of embankment formation was first brought to the notice of the Indian Government by Mr. W. G. McIvor, superintendent of the Government Chinchona Plantations at Ootacumund; and although the prineiple met at first with much opposition from certain leading Government engineers, that gentleman was ultimately intrusted with the duty of carrying out the above-named work, as an experimental measure, under his own individual superintendence.

Twelve miles and a half from Ootacumund in a southwesterly direction, and near the Avalanche, is a stream of water called the Porty River. This stream flows through the valley between the Khoondahs and Neilgherry hills, and is the main branch of the Bhowany River, which, finding its way to the low country near Mettapolliem, and flowing through the Coimbatore district, empties itself into the Cauvery. This river winds its way between the hills, and at a point where, by their converging together, the valley between is narrowed, the embankment is being thrown across from hill to hill; it will be over a quarter of a mile in length at the top, and will rise to a height of 150 ft. above the level of the bed of the river, throwing back the water and forming a magnificent lake 5 miles in length by 2½ miles broad. Several hills which now appear of considerable magnitude will be submerged, and others rising to a greater height will show but their heads above water, dotting the lake here and there with islands. This lake will contain 30 million cubic yards of water, and to withstand its enormous pressure, the embankment at its base is 700 ft. thick. The estimated total cost of this gigantic work, including the construction of an under-sluice or culvert, is only 25,000 rupees, or £2,500.

The two requisites for this silting process are a stream of water above the level of the top of the intended embankment, and a supply of earth sufficient to form the dam. The nearest available hill supplies the latter, while one of the streams in use for the former purpose has been brought from a distance of about 10 miles. The hill to supply the earth having been selected, and the silting stream brought to the scene of operations, a trench some 6 ft. deep is cut along one side of the hill, which is continued by means of a narrow channel to the spot where the embankment is to be formed. At both ends of the intended bund a deep and wide trench is formed, extending from hill to hill and the earth thrown up on the outer side, or else the whole of the earth on the spot where the intended bund is to rest is taken away; the object being to remove the surface earth, roots of trees, etc., which on decaying would allow the water to percolate through the soil under the dam. In either case a low wall of earth is formed by heaping up the mud at either end of the intended bund, just sufficient to confine the water coming from the silting stream.

The water from the stream being turned over the hill-side, detaches the earth, which, falling to the bottom, is carried away in the trench to the spot where the bund is to be formed. Arrived here the silt-charged stream flows over the enclosed area, where, being ponded in, it deposits its burden, thus gradually raising the bund inch by inch in height, and the clear water is then allowed to flow away through a small orifice made in the mud wall at the opposite end of the bund. Thus the work is continued night and day, all the attention required being the services of a man to keep an outer wall of earth always slightly higher than the constantly rising bund, to prevent the immediate escape of the water and give time for the silt to deposit, and to bring the silting stream alternately into the opposite ends of the bund. The object of this latter operation being to make the bund of uniform

strength, for as the silt is the first to be deposited, that part of the bund where the stream enters receives the heavier particles, while the lighter sediment in suspension, taking a longer time to deposit, falls on the more distant part, and so by alternating the entrance and exit of the stream, silt and sediment are deposited evenly over the bund in alternate layers.

So far as the work has hitherto progressed, its success has been complete, and we learn that some of those engineers who previously doubted the soundness of the principle have now become willing converts. Upon the success, however, of the Neilgherry experiment—which may now be said to have been insured—there depends a still more important project. Besides the heavy rain-fall that deluges Travancore every southwest monsoon, the country to the sea is lavishly watered by rivers from the Western Ghauts, while Madura, on the other side of the water-shed, has few streams and less than 30 in. of rain. It is accordingly proposed to form a bund, by this silting process, across the channel of the Perriar flowing to the west, and thus to divert a portion of its current into the Vigay, a river in Madura, rising near the source of the Perriar in the Western Ghauts. This project, it is expected, will prove very costly; but the importance of the object is considered quite sufficient to warrant the outlay that will be necessary. In the words of Lord Napier, the main difficulty of the work "lies in the construction of a dam of unprecedented magnitude, partly in the bed of a furious torrent, and in a distant, deserted, fever-stricken region."

A YEAR'S STEAM BOILER EXPLOSIONS.

An interesting and elaborate report has been prepared by Mr. L. E. Fletcher, Chief Engineer to the Manchester Steam Users' Association, giving details of the boiler explosions which occurred during the year 1869. Referring first to the work of the Association, we find that during the past year 5,910 boiler examinations were made by the officers of the Association, 3,848 of these being external, 80 internal, 58 in the flues, and 1,924 entire. This is the highest number of entire examinations attained in one year in the Association's history; and, if added to the internal and flue examinations, it amounts to more than one for each boiler enrolled. The result of these examinations was that 1,331 defects were met with, 83 of them being dangerous, many of which would, if undiscovered, have ultimately led to explosion. On the whole, however, Mr. Fletcher reports that the general standard of boilers is improving, greater attention being paid to minor details, the importance of which is beginning to be realized.

Turning to the number of explosions that occurred during the year 1869, throughout the country, we find the total to be 58, by which 86 persons were killed and 126 others injured. If, however, to this be added the two kitchen boiler explosions and the two tar boiler explosions which occurred during the past year, the return for the year 1869 will be 62 explosions, resulting in 92 deaths, and 130 cases of injury. Explosions clearly are not on the decrease, as will be seen from the following table, which does not include those explosions which have sprung from kitchen, from ventilating, and tar boilers:

Return of the Number of Steam Boiler Explosions from the Year 1863 *to* 1869, *inclusive, with the Number of Persons Killed and Injured thereby.*

Year.	Number of Explosions.	Persons Killed.	Persons Injured.	Total.
1863	48	76	80	156
1864	32	64	90	154
1865	48	46	79	125
1866	72	87	109	196
1867	36	60	67	127
1868	45	57	60	117
1869	58	86	126	212
Total for 7 years	339	476	611	1,087
Average for each year.	48	68	7	155

From the foregoing table it will be seen that the number of explosions during 1869 was above the average, and supports the estimate given on previous occasions, that,

as a rule, one steam boiler explodes every week, or in round numbers 50 explode every year, killing 75 persons. As in previous years, the scene of the catastrophe has been visited in the majority of cases by officers of the Association, and the cause of the explosion investigated, full particulars being recorded at their offices. From these records Mr. Fletcher has prepared an elaborate tabular synopsis of the explosions that have occurred during the year 1869, which give the pith of the information respecting them. The length of this synopsis excludes it from our columns, but to the members of the Association, and in fact to all steam users, it will prove valuable as a record for reference as to cause and effect in these lamentable catastrophes. For further convenience, however, Mr. Fletcher has arranged the 58 explosions recorded in the tabular synopsis under three heads. One the service in which the boilers were engaged, another the general class or construction of the boiler in each case, and the third the causes from which the explosions sprung. These are given in the following tables :

TABLE NO. 1,

Showing the Service in which the Boilers were engaged from which Explosions arose in the Year 1869.

Description of Service.	Number of Explosions.	Persons Killed.	Persons Injured.
Collieries	16	20	21
Tin and other mines	10	2	2
Ironworks	5	15	11
Steamboats and Steam Tugs	4	17	10
Paper Mills	3	2	6
Agricultural	2	2	5
Locomotive	2	0	2
Iron Founders and Nail Cutters	2	2	4
Bobbin Turnery	1	15	33
Steam Crane	1	4	3
Cotton Mill	1	1	2
Woolen Mill	1	0	4
Miscellaneous :—1 Rice Mill ; 1 Saw Mill ; 1 Bleach Works ; 1 Brick Works ; 1 Chemical Works ; 1 Oil Works ; 1 Shipbuilding Works ; 1 Tin Works ; 1 Wire Works ; 1 Gun Implement Manufactory	10	6	23
Total	58	86	126

On a consultation of the above table it will be seen that more explosions occurred, as in previous years, at collieries, mines, and ironworks, than at any other works, while those at ironworks were of a much more fatal character than those either at mines or collieries. Numerous as cotton and woolen mills are, only one explosion occurred at a cotton mill, and one at a woolen mill. The following table shows the class of boiler from which explosions arose in the year 1869 :

TABLE NO. 2,

Showing the different Classes of Boiler from which Explosions arose in the Year 1869.

Description of Boiler.	Number of Explosions.	Persons Killed.	Persons Injured.
Plain cylindrical, egg-ended, camber-ended, and flat-ended (externally fired)	21	20	38
Single-flued or Cornish (internally fired)	14	12	15
Double-flued or Lancashire (internally fired)	4	17	38
Multitubular marine type (internally fired)	4	17	10
Double furnace "breeches," and double furnace patent conical water tube (internally fired)	3	3	3
Portable, vertical, and locomotive type (internally fired)	3	5	8
Railway locomotive, multitubular (internally fired)	2	0	2
Furnace boilers, heated by flames passing of from iron furnaces :—			
One horizontal double-flued (internally fired)	1	2	6
One vertical (externally fired)	1	8	1
Wagon (externally fired)	1	0	2
Rag boiler (no fire, heated by steam)	1	1	2
Particulars not precisely ascertained	3	1	1
Total	58	86	126

On a consultation of the above table it will be seen that more explosions arose from, and more persons were killed by, the plain cylindrical, externally-fired class of boiler than any other. The introduction of the internally-fired Lancashire boiler in the place of the plain, cylindrical, externally-fired, would certainly be productive of safety, and it is thought, of economy.

All boiler explosions may, as a rule, be attributed to the neglect of the boiler maker, the boiler owner, or the boiler minder. Looking at the following table, it will be seen that 26 explosions were due to the boiler maker, 15 to the boiler owner, and 7 to the boiler minder. While

it is important that it should be known that a large proportion of the explosions that occur are due simply to bad boiler making, it should not be overlooked that the boiler maker is very much under the influence of the boiler owner, and, therefore, the responsibility must be shared between the two, which gives the boiler maker and the boiler owner together 41 explosions to answer for, against 7 by the boiler minder, or 6 to 1.

The third table shows the causes from which explosions arose in the year 1869 :

TABLE NO. 3,

Showing the Causes from which Explosions arose in the Year 1869.

Cause of Explosion.	Number of Explosions.	Persons Killed.	Persons Injured.
Malconstruction :—			
External firing.....11			
Collapse of flue tubes... 7			
Weak manholes..... 4			
Want of stays..... 4——	26	28	43
Defective condition :—			
External corrosion..... 8			
Internal corrosion..... 7——	15	33	56
Overheating through shortness of water.....	7	10	11
Overheating from the use of boiler compositions	1	0	0
Overheating—but cause of overheating requires further investigation.	1	11	7
Cases in which full particulars have not been obtained.....	8	4	9
Total	58	86	126

The above table shows how easily these explosions could have been prevented. The 11 explosions due to external firing could have been prevented by the adoption of the Lancashire boiler, in such general use in the cotton mills in this district, and from which so few explosions arise. The 7 cases of collapse of flue tubes might have been prevented simply by the addition of encircling hoops, flanged seams, or other suitable strengthening appliances. The 4 weak manholes could have been strengthened with mouthpieces. The 4 cases of want of stays could have been corrected by due calculation. The 15 plates wasted by external and internal corrosion might have been detected in time to have prevented explosion by competent examination, while the 7 cases of overheating through shortness of water, though due to neglect of attendants, might, in the majority of cases, if not in all, have been prevented by a liberal complement of fittings, and the adoption of a low-water safety-valve. Thus the causes of nearly all explosions are under control, and these disasters, as has been said on so many previous occasions, may, as a rule, be prevented by the exercise of common knowledge and common care.

Simple as the causes of these explosions were, the investigations conducted by coroners with regard to them were, in the majority of instances, most unsatisfactory, and the verdicts positively mischievous. Too frequently only incompetent witnesses were examined, and explosions resulting from glaring defects in the boilers were pronounced to be *inscrutable* and *inevitable ;* in consequence of which, boilers as deadly as those which had given rise to the explosions under consideration were allowed to be worked on without warning, at the peril of the lives of the poor men around them.

Constant reference to these subjects may appear monotonous, but those who are brought face to face with the devastation produced by these catastrophes are stirred with a strong sense of indignation at such evidence on these occasions. In one instance to which reference may be made, six persons were injured, one of them fatally, as well as a woman widowed and a family orphaned, simply by the explosion of a grossly malconstructed boiler ; yet, on an investigation by a learned coroner and his jury, the catastrophe was pronounced to be *accidental*, and every one connected with it acquitted of responsibility. The man was killed, and he must be buried, but it could not be helped, and there was an end of the whole matter. The owners were at perfect liberty to set to work another boiler, as defective, and, therefore, as deadly as the last, and to work on till another explosion should occur, and other men should be slaughtered, as well as others injured, other women widowed and other children orphaned ; when again, by the help of another learned coroner and his jury, the whole transaction would be once more condoned, the boiler pronounced good, the owners careful, and the only remaining duty declared to be to bury the dead out of sight of the living, and to go on as

before. Such is a simple recital of an almost every-day occurrence, and the question arises, how is it that such a state of things is allowed to exist? The answer is a simple one. Those who are killed are only poor stokers, who are too friendless and too ignorant to defend themselves. Let 75 boiler owners be blown to pieces this year instead of 75 of their firemen, and then boiler explosions would at once cease to be considered mysterious, the cause of each would become as clear as daylight, and their recurrence would be at once put a stop to. At all events, the Manchester Steam Users' Association is resolved to be clear in this matter. It has for years investigated the circumstances attending nearly every explosion that has occurred, and circulated broadcast sound information with regard to their cause. It has endeavored to sweep away all mystery with regard to this subject, and to show steam users how to prevent the explosion of their boilers, and the slaughter of their workpeople; and as long as explosions continue to occur, from the use of glaringly malconstructed and old worn-out boilers, it will persist in circulating as widely as possible full particulars with regard to them, and in declaring that explosions generally are not the result of accident but simply of neglect, and that they might be and ought to be prevented.

SEWAGE AND THE LAND.

From "The Builder."

In the course of the discussion which followed the reading, by Mr. W. Hope, at the Society of Arts, of a paper "On the Use and Abuse of Town Sewage,"

Mr. R. Rawlinson, C.B., said he believed the most difficult land to irrigate would be a large area of comparatively flat land. He believed the most favorable was that having a limited contour elevation, and he should not even object to rather steep gradients in some instances, provided that the sewage at the commencement was sufficient for gravity, even if they had to go to some expense for pumping. His reason was this, that in irrigating land having a considerable fall, the engineer could pass his sewage by contour grips and lines over the upper areas, could then get it over the intervening portions into a second line of carriers, and as it was almost impossible to take out all the fertilizing qualities of sewage by once passing it over and through any table-land area, he could pass it over twice, thrice, or even four times beneficially, and he could then discharge the water from the last carriers as pure as ordinary spring water. He did not say they would ever arrive at that pitch of perfection when it would be safe to recommend the clarified water from subsoil drains for culinary and drinking purposes, although he knew at that moment of an instance in which the strongest sewage he ever heard or knew of was used by the adjoining residents in this way as it flowed from the subsoil drains, and that was at the farm at Aldershott; and as this was the most perfect system of sewage irrigation that had come under his observation, a word or two in description of it might be allowed. It was perfect in every respect, not only because the difficulties overcome were the greatest, and the sewage by far the strongest, but because the results were by far the best. The Aldershott Camp Sewage Farm consisted of about 98 acres of land, which was, as an old north country farmer once said, worth "nowt" an acre. It was absolutely worthless, consisting of 90 per cent. of sand, with a mixture of peroxide of iron, which was absolutely poisonous. Mr. Blackburn, the engineer who had charge of the works, and who, fortunately, had had some experience in agriculture, broke up the subsoil, washed out the peroxide of iron, drained it, and laid it under a sewage irrigation of from 200,000 to 400,000 gals. per day, the sewage coming from the camp, and containing 20 grains of ammonia in the gallon; and an analysis showed that, while it had 20 grains of strong phosphoric acid to the gallon as it flowed on the land, the water from the subsoil drains only had half a grain. Mr. Blackburn said it was of no use to irrigate land with sewage on the surface, or to plough it in the ordinary way; he invented a plough for the special purpose, and broke up the subsoil to a depth of 20 in., and having

irrigated that well with sewage, he got a crop of Italian rye grass of from 70 to 80 tons to the acre. After two years he laid down a breadth in potatoes, which he sold on the ground at £25 per acre, the purchaser being at the cost of digging and taking them away, and leaving the tops behind as a solid dressing for the land of considerable value. In the same autumn the land was broken up, prepared and sown with Italian rye grass, which he himself saw showing 2 in. above the surface. If, however, a good profit was to be made out of land irrigated with sewage in the vicinity of a town, it should be made to produce every kind of garden produce used in the community, all kinds of grain crops being avoided, as entailing only waste of labor, land, and money. Italian rye grass, mangolds, potatoes, cabbages, French beans, and lettuces, could all be grown with advantage, but they required special knowledge and special care; for some must not be irrigated at all while the crop was in the ground, whilst others required quite a different treatment. In this way as much as from £100 to £200 per acre of gross receipts might be obtained, for he had seen a return made by persons on whom he could place implicit confidence, showing with a crop of cabbages and cabbage-plants a gross return equal to £200 per acre. Between this and the ordinary produce of £5 to £10 per acre was a wide margin, quite sufficient to induce efforts in this direction. They were on the threshold of this question, and only just beginning to understand it; and as there had been so much joint-stock enterprise of late, he would suggest to any gentlemen who wished to make their fortunes that they could not do better than form an honest company and go to some of the distressed towns which had been described as in the clutches of the Vice-Chancellor, and treat with them for their sewage and the land necessary to utilize it. He knew many towns which would receive them with open arms, and let them have the land at a fair agricultural price, and let them have the sewage in for nothing; and if there was any truth in chemistry, this could hardly be a bad bargain. But, at the same time, it must be conducted with knowledge and care, for he himself was concerned in a speculation of that kind where both the sewage and the land were as good as any in England, and the climate propitious; but, owing to defective management in some way, they only got a dividend of 1½ per cent., whereas, by letting it in the ordinary way, having bought it on good terms, they could have realized 5 per cent. There were, therefore, two sides to the sewage shield, as to most others; but he believed, nevertheless, that in the proper application of this system there was a mine of wealth, by bringing common sense to bear, and avoiding blunders which had already been committed. On the other hand, in many places it had become a sheer necessity to do something of this sort, in order to avoid poisoning the rivers, and would be more and more so every day. Before sitting down, he would say that the man who could solidify sewage and make it a portable manure, could invent perpetual motion and square the circle. The most perfect chemical researches had yet failed to do more than take out one-seventh of the valuable properties of sewage in solid form; and taking a ton of sewage as being worth 17s. 6d., and treating it in any possible way—and he spoke from having been associated on the Commission with some of the first chemists of the day—the result would be to take out solid matter to the value of 2s. 2d., and leave 15s. 4d. worth to go away with the effluent water, which might nevertheless appear perfectly pure and bright. On the other hand, when liquid sewage was passed through 20 in. of soil, it had but the barest trace of these valuable salts left in it. This, therefore, was the only true and profitable chemistry.

Steel Boiler.—At the Fort Pitt Iron-works, Pittsburg, Pa., a cylindrical boiler was constructed last year of steel plates ¼ in. in thickness, by that establishment, for the Government, with a view to testing its adaptability to such use, relatively with the iron. It was tested with cold water in presence of the proprietors of the works, the Government engineer officer—under whose supervision it was built—the eminent constructing and mechanical engineer Thatcher Perkins, and others. Measurement of the girth of the boiler was made, with a steel tape, before and during the process of pumping in cold water, and when the pressure reached 780 lbs. an enlargement of 3¾ in. was found to exist, and at 820 lbs. rupture occurred.

DE-RAILMENT OF RAILWAY TRAINS.

From "Engineering."

All engineers who have had experience in railway management are familiar with cases in which accidents have arisen from engines or carriages leaving the line without, apparently, any sufficient reason. No doubt in the vast majority of instances, when a train leaves the line, there is evidence to prove why the de-railment took place; but this is not always the case—and in many an instance the subsequent investigations which have been made have failed to show the causes which led to the accident. Now, an accident which is accounted for is bad enough; but an accident which is unaccounted for is far worse, for in the latter case no experience is gained which may lead to the avoidance of a disaster in future. For this reason we consider that whenever a mishap of the kind of which we are speaking occurs, no trouble should be spared in determining, if possible, its real cause; and if this cause is one which is not generally known, information concerning it should be disseminated amongst those whom it interests. It has been often stated that a record of engineering failures would be more instructive than an account of engineering successes, and to no class of failures does this remark apply more truly than to railway accidents.

We have said that there have been many instances in which trains have left the line without, apparently, any sufficient reason, and it is of this class of railway accidents that we wish to speak here. And, first, as to the ordinary causes of de-railment. These are: Weak or uneven permanent way, bad joints, wheels with flanges worn to a sharp edge on the outer side, and curves worked by engines or vehicles unfitted to pass round them. Where any one of these causes exists there is no difficulty in accounting for a case of de-railment; but when none of these are present—when the permanent way and wheels are in good order, the speed of the train not excessive, and when the accident does not occur on a curve—we have to search further for the causes which give rise to the mishap. When a train is running at a fair speed on an ordinary line of railway, the rails receive a succession of lateral blowsfrom the wheel flanges; these blows—which are more or less severe according to the state of the road and the construction of the rolling stock—being nothing but a series of endeavors on the part of the train to "run off." Now, supposing the tyres and permanent way to be in good order, and the line to be straight, "running off" can only occur when the force with which any wheel flange strikes the rail laterally is sufficient to cause that flange to act as a kind of inclined plane, lifting the weight resting on that wheel and thus causing "mounting." It may at first sight appear that, considering the forms of tyre and rail section in ordinary use, no amount of lateral force which is likely to be available would suffice to cause the lifting of the weight upon the wheel in the manner we have just mentioned; but a little further investigation of the case will show that the possibility of such an action certainly exists. Let iron templates of ordinary tyre and rail sections be taken and placed together in the manner in which a wheel bears upon a rail, and let a pressure be then applied to the inner edge of the tyre template, when it will be seen that the latter can be readily made to rise from its bearing upon the rail. In the case of an ordinary engine or carriage, this mounting under the influence of lateral pressure is prevented by the weight insistent upon the wheel, and we thus see that in the steady maintenance of this weight lies one of the principal safeguards against de-railment.

This brings us to the question as to how much the insistent weight upon the wheels of an engine or carriage varies when running at moderately high speeds; and this is a question to which no precise answer can be given. That the load on the wheels does vary—and vary considerably too—is clearly shown by the play of the springs; but the degree of maximum variation depends so greatly upon the construction of the rolling stock, the manner in which it is loaded, and the state of the permanent way, that not even a general statement of its amount can be given. That, however, this variation is in many cases very far greater than is usually supposed, is proved by some interesting experiments on the subject which have been made by M. de

Weber, of the State Railway of Saxony. These experiments, which have been made, by the aid of suitable arrangements, on six-wheeled engines, having, we believe, all the axles under the barrel of the boiler, show very startling results. They show that in the case of trailing wheels carrying a normal load of 5¾ tons each, the load when running varied from 10 tons down to 1½ tons; while in the case of leading wheels having each a normal load of 3½ tons, the load when running varied from 8 tons down to zero! Now, although we should hope that such an occurrence as the total removal of the load from one of the leading wheels of an engine is an exceptional one, yet the fact that it occurred during M. de Weber's experiments proves that it is likely to occur again under certain conditions; and it is certainly more than probable that if this removal of the load took place simultaneously with a severe lateral blow of the flange of the wheel against the rail, "running off" would be the result. M. de Weber's experiments, in fact, go to show that most of the "mysterious" de-railments which have occurred have probably been due to this simultaneous occurrence of a severe lateral pressure, and an upward oscillation of the load on the springs of the particular wheel which has mounted, this action being in many instances further assisted by one of which we shall now proceed to speak.

In addition to his experiments on the variation of load on wheels of engines when running, M. de Weber has made a number of others on the lateral stability of permanent way, and although these experiments were carried out on the somewhat light rails of the State Railway of Saxony, the results obtained possess considerable general interest. When a line of rails is subjected to a lateral pressure, applied to the side of the head of the rail at any one point, it may yield by the flexure of the rail itself, by the turning of the rail on its base, or by the direct movement of the sleepers on the ballast; and as far as the two last mentioned causes are concerned, it will be found that the amount of yielding which will take place will be greatly modified according to the load which the rail is carrying at the time when the lateral pressure is applied. Thus, M. de Weber found that the resistance of the sleepers to lateral movements on the ballast was increased tenfold, as compared with the same line unloaded, by the imposition of a load of 28 tons; while in the case of the Vignoles rails, on which the experiments were tried, a force of 2¾ tons, which produced an enlargement of the gauge to the extent of 1½ in. when the line was unloaded, produced a spreading of but ¼ in. only when the rails were carrying a load of 11 tons on a pair of wheels. These results show that the relieving of the wheels of weight by the vertical oscillations not only facilitates mounting, but also diminishes the lateral resistance of the rails to a spreading of the gauge, and it thus tends to produce de-railment in two ways. M. de Weber's experiments thus go very far to explain the cases of "running off," which are not accounted for by ordinary causes, and we should be glad to see them followed up by similar experiments on the engines and forms of permanent ways in general use in this country.

MARBLES.—The chief place of the manufacture of marbles is at Oberstein, on the Nahe, in Germany, where there are large agate mills and quarries, the refuse of which is carefully turned to good paying account by being made into the small balls employed by experts to knuckle with, which are mostly sent to the American market. The substance used in Saxony is a hard, calcareous stone, which is first broken into blocks, nearly square by blows with a hammer. These are thrown by the 100 or 200 into a small sort of mill, which is formed of a flat, stationary slab of stone, with a number of concentric furrows upon its face. A block of oak or other hard wood, of the same diametric size, is placed over the small stones and partly resting upon them. This block, or log, is kept revolving while water flows upon the stone slab. In about 15 minutes the stones are turned into spheres, and then, being fit for sale, are henceforth called "marbles." One establishment, containing only three of these rude mills, will turn out full 60,000 marbles in each week. Agates are made into marbles at Oberstein, by first chipping the pieces nearly round with a hammer, handled by a skilful workman, and then wearing down the edges upon the surface of a large grindstone.

THE MANUFACTURE OF STEEL.*

From "The Journal of Applied Chemistry."

It is hardly necessary to say that this is the most complete, accurate, and valuable treatise on the metallurgy of steel that has been published at any time, in any language. Prof. Kerl put into the book the results of his patient study of the subject, and the English editors have contributed the latest improvements and newest practical information from the immense iron workers of Great Britain. We have in this way the best possible combination for a complete work on the subject. The printing, paper, and illustrations are in harmony with the thorough and comprehensive design of the book, and it is with unalloyed satisfaction that we apply ourselves to the task of reviewing it.

We cannot do better at the outset than to quote a few words from the preface. The authors say: "Owing to the complexity and vastness of the subject, and to the continued development of new processes and inventions, the task of the authors has proved by no means easy, but they trust that they have succeeded in producing, in a compendious and somewhat complete form, a work of practical value to the metallurgist. While the authors have taken the admirable treatise of Prof. Kerl as the groundwork of their labors, they have given much practical information and many useful processes, which are not to be found in Kerl." A glossary of technical terms and tables of weights and measures are given at the end of the volume.

The book opens with a definition of steel: "Steel differs from pig and wrought iron in its proportion of carbon (1.4 or 1.5 per cent.); it differs from pig-iron in its property of welding, and from wrought-iron in its fusibility; its melting point is about 1850 deg. C., whilst the melting point of pig-iron is between 1400 deg. and 1600 deg. C. Steel is furthermore characterized by its softness at a glowing heat, and by becoming hard upon sudden cooling. These properties are modified according to the proportion of carbon, the presence or absence of certain foreign admixtures, the uniformity of its mechanical treatment, the method employed for its production, and finally, to other circumstances which are not yet well understood."

PROPERTIES OF STEEL.

"Steel is whitish gray, or white and dull, with a silky fracture; its texture is fine-grained, the grain being of an indefinite, jagged shape, and somewhat lighter and finer in tempered steel than in soft steel. Tungsten steel shows a perfectly conchoidal fracture on which the grain is so fine as to be scarcely preceptible. Natural steel in the original balls, and cement steel after cementation, as well as cast-steel immediately after being cast, shows a coarse non-uniform appearance, and has but little tenacity; but the grain will become finer if the steel is drawn out at suitable temperatures to very small dimensions; and if a very high temperature has been employed in its tempering, slowly cooled steel maintains its original texture, and hardened steel retains it if re-heated, and slowly cooled. This circumstance must be taken into consideration when judging the quality of steel from the appearance of the fracture, as steel is usually considered to be of a superior quality if its grain is very fine. The appearance of the fracture may prove the uniformity of steel, but does not indicate its other properties—hardness, tenacity, etc. These qualities depend on the quality and quantity of the foreign admixtures contained in the steel, and can only be detected by direct trials and tests.

"The specific gravity of steel ranges between 7.5 and 8.0, and is diminished by hardening. The following table shows the specific gravity of Bessemer steel of various degrees of carbonization made at Sandviken in Sweden:

SPECIFIC GRAVITY

Percentage of Carbon.	Soft.	Hardened.
1.5	7.785	7.736
1.2	7.832	7.771
0.9	7.874	7.808
0.6	7.879	7.807
0.4	7.893	7.839

"The hardness of steel varies with its

* A Practical Treatise on Metallurgy; adapted from the last German edition of Prof. Kerl's Metallurgy. By William Crookes, F. R. S., and Ernst Roehrig, Ph. D., M. E. In three volumes. Vol. III. Steel; Fuel, Supplement. Illustrated with 145 wood engravings. Royal 8vo., pp. xxxii., 820. John Wiley & Son, 2 Clinton Hall, Astor Place, New York. 1870. For sale by Van Nostrand.

proportion of carbon. The steel poorest in carbon is the least hard, and the steel richest in carbon approaches white pig-iron; but its other properties, strength, fusibility, weldability, etc., are then modified. Unhardened steel with the proper amount of carbon, 1.4 or 1.5 per cent., is but little harder than wrought-iron. The tensile strength of steel considerably exceeds that of wrought-iron. The transverse strength is likewise very great, and the crushing strength varies with the hardness of the steel.

"The influence of foreign substances upon steel is in many cases unfavorable, chiefly by impairing its tenacity and elasticity; this influence is exerted by sulphur, phosphorus, silicon, copper, etc.; other substances have a favorable influence, but it is still doubtful whether they always enter into combination with the steel, or merely have a purifying effect by combining with the injurious substances present, and thus separating them, as is the case with pig-iron. Manganese facilitates the formation of steel, and purifies it, although only a little enters the steel in combination. Tungsten steel shows an exceedingly fine, conchoidal, silk-like fracture, combining great hardness and density, and is superior in tenacity and weldability to all other steel. Notwithstanding its reputed qualities, tungsten steel has not been generally introduced, probably owing to the high price or the scarcity of wolfram. Perhaps steel was sold as tungsten, which did not contain any tungsten, or else its reputed qualities are somewhat exaggerated.

"According to Mr. Musket, titanium acts upon steel in the same way as tungsten, when titaniferous iron ores, or other iron ores, with titaniferous fluxes, are smelted for the production of grey pig iron (not white pig, as in this case the most titanium will enter the slag), and the grey pig iron is worked into natural or cement steel. More recent observations show that titanium, as well as tungsten, seems to enter steel in larger proportions, and to improve its quality."

After giving very fully the properties of steel from which we have condensed the above statement, the authors enter upon a description of its manufacture in various countries, and according to different processes. They then devote a large portion of the work to the discussion of the important question of fuel and the utilization of waste gases; and finally, in the supplement is contained a rich store of matter, from which we shall hereafter make copious extracts for the benefit of such of our readers as cannot afford to purchase the book. We regret to be obliged to say that considerable carelessness has been shown in the choice of language in the translation of many passages; but as the facts are accurately given, the language in which they are clothed must be of secondary importance.

Trial Trip of a Fairlie Engine.—The Burry Port and Gwendraeth Railway is the first construction under the recent Act of Parliament, which enables a railway company to lay a light rail for the permanent way, and is quite an experiment in light and cheap railways. The above-named company, in order to protect their permanent way as far as possible, have purchased a new engine built on the bogie principle adapted to locomotives and railway carriages, by Mr. Fairlie. Her cylinders are 10 ft.; each boiler is 9 ft. long, and 2 ft. 11 in. diameter inside, and contains 168 tubes; the fire-box is 5 ft. long; the wheel base is 5 ft. and the diameter of the wheel 3 ft. 6 in.; length of tube 18 in.; and length of engine 33 ft. The trial trip was made on Wednesday, on the line from Pembrey to Portyberem, a distance of 11 miles. The weight of the train was 150 tons 17 cwt., and of the engine 23 tons 10 cwt., making a total of 174 tons 7 cwt. The engine started from a state of rest at the bottom of an incline of 1 in 36, and 14 chains long. This she failed to ascend at first, owing to the slippery state of the rails, but a little sand being applied she went up easily. She pushed on very well for 8 miles 34 chains, which is a continually rising gradient. The distance was traversed between 12.23, the time of starting, and 12.49. At this point of the line there is an incline of 1 in 45, which she failed to ascend with three attempts; the pressure was then raised to 100 lbs., 48 tons 8 cwt. were taken off, and she ascended the incline easily. The coal used was said to be small and choked the tubes. She was considered by a number of practical gentlemen who were present to be equal to a load of 120 tons up an incline of 1 in 45, and will probably go from 17 to 20 miles an hour. The trial was very satisfactory.—*Engineering.*

STEEL FOR TOOLS.

We extract from "Engineering" the following remarks in regard to Mr. Robert Mushet's "special steel," manufactured by the Titanic Steel and Iron Company, of Coleford, and a very peculiar material it is. Of the process of its manufacture we know nothing; but of the quality of the material itself when used as a cutting tool we have latterly had an opportunity of judging, and we have been led to form a high opinion of it. One of its main peculiarities is that it does not require hardening, or rather, to speak more correctly, that it only requires hardening by a light cold-hammering, and not by dipping in the ordinary way. A fractured bar, when examined by the microscope, shows a remarkably close and even texture, the grain in fact being so fine that it is barely distinguishable by the naked eye. When heated to a low red heat it can be forged without any great difficulty; but like all good tool steel it requires care on the part of the smith, and a bar should not be drawn down much without reheating. When a tool has been brought to the required shape it should be lightly but thoroughly cold-hammered, and then put aside to cool gradually. When cold it only requires grinding to be fit for use.

Amongst the firms who are now using Mr. Mushet's steel extensively are Messrs. John Fowler and Co., of the Steam Plough Works, Leeds; and it was at their works that we last week had an opportunity of seeing a number of these "unhardened" tools in use. Messrs. Fowler, as is well known, use steel forgings and castings very extensively in the construction of their engines—in fact we do not hesitate to say that their requirements alone have given a most important impetus to the manufacture of such castings in this country—and the quality of the tool steel they employ is thus to them a matter of considerable importance. The taking a slight cut, scarcely more than skin deep, off the inner faces of the deep flanges of the steel winding drums, and the series of intermittent cuts which have to be taken in turning up the faces left on the arms of these drums, etc., are pieces of work which test the quality of tools as much as it is perhaps possible to test it, many of the castings notwithstanding the annealing to which they are subjected having skins so hard, particularly in the angles, that it is with difficulty a tool can be got to act upon them at all. It is for this class of work that Messrs. Fowler are now using Mr. Mushet's steel, and they are gradually replacing all their lathe and planing machine tools with this material. At a planing machine we found some of these tools in use planing locomotive coupling rods (iron), about 7ft. long, between centres, the average work done by each tool, without grinding, being to take a finishing cut over all sides of one rod, and a similar roughing cut over the next; while at an adjacent machine was a tool which had been in use planing for seventeen hours without requiring to be taken to the grindstone. Similar tools had been planing cast-iron fifteen hours, and turning steel axles six hours—the surface speed of the axle being 20 ft. per minute; while one tool had been planing steel horn-blocks twenty-five hours. Perhaps, however, the best evidence of the value of this material is to be found in the behavior of the machine men at the Steam Plough Works, who are all on piecework, and who, when turning or planing steel, invariably use the tools of which we have been speaking, if they can possibly get them, as they enable them to run their machines at a higher speed, and avoid loss of time in grinding and making changes. So far we have only spoken of the value of the material when used for operating on steel; but the same qualities which give it value in this case render it equally valuable for turning or planing wrought or cast-iron. For chisels or other tools operating by a percussive action it is not suitable, as, although not objectionably brittle, it is not of such a nature as to bear blows well. Of its adaptability for drills we have no experience, but there is such an ample field for its employment in other forms that it is of little consequence whether it makes good drills or not. In conclusion we may state that we have spoken of Mr. Mushet's "special steel" at some length, because we regard it as a very peculiar and valuable material, the properties of which deserve to be even more widely known than

they now are, and which, we believe, only requires to be fairly treated to gain a reputation which will lead to its extensive employment for turning and planing tools in all establishments where there is hard work to be done.

THE STONEWORK OF THE HOUSES OF PARLIAMENT.

From the "Pall Mall Gazette," through the "Building News."

The condition of the stonework of the New Houses of Parliament is at last beginning to attract serious attention. When pieces of masonry varying in weight from 5 lbs. to 10 lbs. or 15 lbs. come crashing down, it is no wonder that some uneasiness should be felt, at least by those who reside in the Palace, or whose duties take them thither. Only a short time since a piece of carved work, weighing between 70 lbs. and 80 lbs., fell from the summit of the Clock Tower upon the roof of the house below, inhabited by the record clerk of the House of Commons, Sir Thomas May. It passed through the iron roof as if it were so much paper, broke an iron girder, and was stopped only by the stout brick arches beneath. Another time a piece of about 18 lbs. weight fell into one of the courts and was shivered into fragments just after no less a personage than the Usher of the Black Rod had passed through. At another time a fragment weighing about 10 lbs. fell at the feet of the policeman on duty outside the entrance into Westminster Hall, at the south end, just opposite the Abbey. During every considerable storm a shower of pieces of stone, from the size of a walnut to an orange, rattle down upon the iron roofs. We believe, indeed, there is a special functionary appointed to go about the roofs and rake the débris into heaps. There is never any certainty as to when or where these sculptured morsels are going to fall; and the River Terrace, where on summer nights the members walk and smoke their cigars, is not likely this year to be so much frequented as usual. More pieces break off from the carved terminals supporting the gilt vanes than from any other parts; the reason being that the rods which carry the vanes are of iron instead of copper, and as the iron oxidizes it swells and splits the stone. In no remote time this defect is likely to cause the destruction of the upper parts of all the pinnacles. The only change likely to do much good is to substitute copper rods for the rods of iron. Besides this, the stone is rotting deeply in broad discolored patches, in regular lines all round what are called the string courses. Before it has been forty years in existence the New Palace of Westminster shows far greater signs of external decay than many structures of ten times its age. Certainly if reports, inquiries, commissions, and committees could have done any good, the New Houses of Parliament ought to have been about the soundest buildings ever reared. In the first instance a commission of scientific men and architects was appointed to ascertain the best kind of stone to be employed. These commissioners must have had what the Americans call a good time of it in prosecuting their inquiries, for they appear to have visited every castle, abbey, and ancient house in England. In the end they recommended the use of a magnesian limestone, geologically called dolomite, which abounds in Derbyshire, and of which Bolsover Castle, still in fine preservation, though of the date of 1680, is built. So various is the quality of this stone that the same quarry will furnish the best and closest-grained seams and the most porous and most worthless. Sir Charles Barry, we believe, wished that an experienced practical man should be appointed to examine all blocks sent from the quarries. But the Government did not see the necessity of this recommendation, and the post was never properly filled. Two quarries were selected in Derbyshire—the Mansfield and the Anston. The former, unfortunately, could only furnish a small supply, but what it yielded was of excellent quality. The Anston quarry had an abundant supply, and of this the New Palace is mainly built. The difference between the two kinds of stone is now as easily distinguishable in the external walls of the building as the difference between brick and marble. The Mansfield stone is as sharp and

true in outline as when it left the mason's hand; the Anston stone in all exposed positions is fast rotting away. Experiments which have been made show that some of the stone employed is of a most porous kind; indeed, a cube of stone nine inches square was found to be capable of absorbing no less than three pints of water in forty-eight hours. How many gallons, then, would the whole building absorb during two or three days' heavy rain? and what must be the result when in winter the rain is followed by a frost expanding the absorbed water into ice? As a matter of course the delicate carvings must crack into splinters. The process of decay is thus going on steadily and swiftly, and some remedy should be immediately applied. The report recommending the material to be employed in building the New Palace dwells upon the necessity of special care being taken in the selection of stones for the west and south-west faces, as there it says the greatest tendency to decay would always be found to exist. Upon what evidence this theory was based we do not know, but the exact reverse of what was predicted has happened, for it is in the east and north-east faces that the stone has most rapidly decayed. One can, in fact, draw a series of lines round the building where the stones are rotting, and these lines will be found to correspond with what are technically called the string courses, that is, the stone mouldings which project above and below the bands of carved work. Upon these the water drips from above, and then trickles over to those beneath, and so on from top to bottom, till the constant dropping wears away the stone, and the inscriptions are becoming illegible, and the little pinnacle carvings falling away. The same process has gone on, but not to so great an extent, at the Geological Museum in Jermyn street, though the stones of that building, as might have been expected, were carefully examined when selected. It is to be feared, however, that most kinds of dolomite are too porous to withstand the London climate in their natural state. Their pores require closing to protect the surface from the action of moisture, the destructive effect of which is increased by the sulphureous acid which is generated in the London atmosphere by the hundreds of thousands of coal fires always burning. The Caen stone endures our climate better, as we see in Westminster Abbey—much of the east end of which is built of this material; but the Mansfield stone appears to be the best of all in this respect.

Of course when the stonework began to decay, as it did before the New Houses were half finished, the methods proposed for its preservation were almost innumerable, some of them virtually amounting to a plan for rebuilding the whole structure. The favorite device, however, was to coat the stone with various liquid compositions, so as to fill up its pores, and keep them air and water-tight. About twelve years ago two of these inventions were tried on portions of the walls. One was a liquid prepared by Mr. Ransome; another was a solution of silica, the invention of Mr. Szerelmey, a practical chemist, who has devoted his scientific knowledge to the discovery of preservatives against the decay of stone, wood, and iron. A committee, consisting among others of the late Prof. Faraday, the late Sir Charles Barry, and Sir Roderick Murchison, was appointed to decide upon the merits of the competing inventions, and its verdict was in favor of Mr. Szerelmey's plan. The test of time apparently confirms the judgment of the committee, and the composition which it recommended has, after a lapse of 11 years, been re-examined. During the interval that has passed it has been severely tried, having, we believe, been scrubbed with wire brushes and with sand and sulphuric acid. Yet it remains as bright and vitreous as when first put on during a heavy shower of rain. Among other things petroleum, and what is called liquid glass, have also been tried. The petroleum makes the stones look black and greasy, but still it must to some extent fill up the pores, and so for a time retard decay, just as, we believe, the boiled linseed oil has done when applied to the Geological Museum in Jermyn street. As to the water-glass, it is strange that any practical chemist could have thought of it for such a purpose. Water-glass is only silicate of soda. If all the stonework could be immersed in this for a year or so it would form on the outside a silicate of lime—hard and durable enough for all time. As it is, it has merely been smeared on with a brush like any other paint or solution. The carbonic acid in the air

turns the silicate of soda into carbonate of soda, producing a mouldy efflorescence which is easily wiped off with the hand, and leaves the stone as exposed to decay as ever.

Besides these various compositions, another mode of treatment is now, we believe, being pressed upon the attention of the Chief Commissioner of Works. This is nothing less than the cutting out of the decayed parts of the masonry and the substitution of stones of a better quality—in other words, the rebuilding of a considerable part of the Palace. In the end perhaps this remedy may prove to be the only effectual one, but it is obviously a remedy of a very desperate character, and ought unquestionably to be adopted only after all other measures have been fairly tried and failed. We certainly do not think it can be said that this has yet happened. Indeed, there is very strong practical and scientific evidence in favor of at least one of the protective compositions which have been already tried. The plan of cutting out the decayed stones would be very costly—in fact, the cost would be indefinite; once begun it would be difficult to say where it should stop. It is perfectly plain, however, that the present condition of the Palace of Westminster is not only disgraceful, but even dangerous.

MOUNTAIN LOCOMOTIVES.

A correspondent of "Engineering" gives in a recent letter the following interesting details respecting the work of locomotives on heavy grades:—

As a distinct specialty of railway working, mountain railways present some special features, involving a modified mode of transport by steam power. Locomotives cannot be adapted to the exceptional exigencies of undulated lines without sacrificing either speed or train load; the tendency is, and will always be, to maintain this latter as high as possible; a great tractive effort must therefore be produced and utilized at reduced velocity; the speed being also limited, on the other hand, by the smallness of the driving-wheels and small curves. In ordinary locomotives the tractive force, or the "cylinder power," amounts usually to $\frac{1}{5}$ of the weight on the driving-wheels, and this proportion is well justified by experience, as will be seen presently. Upon a clean dry rail a maximum coefficient of adhesion of $\frac{1}{4}$ and even $\frac{1}{3}$ is occasionally attained; but in the course of prolonged working, such an adhesion could not be maintained. In good weather, however, a co-efficient of $\frac{1}{6}$ may safely be counted upon as a normal value, while in winter time the friction is, of course, considerably less. On the Continent, the most precise and reliable information on this subject has recently been furnished by MM. Vuillemin, Guebhard, and Dieudonné, engineers to the Eastern Railway of France. The results of a long series of experiments, made with a traction dynamometer, have been published in a memoir, entitled "De la Resistance des Trains et de la Puissance des Machines." Paris, 1868. Eugéne Lacroix, éditeur. This is a work of great value, and has, as such, obtained the Perdonnet Medal of £80, offered by the late M. Auguste Perdonnet to the Society of Civil Engineers of France, with a view to stimulate such researches. As regards locomotive adhesion, we find in Tables 24 and 25 of this memoir a summary of observations, made with various types of engines and trains, and from these results it appears that, during continued work, the maximum value of the coefficient of adhesion was $\frac{1}{5}$; upon this limit should be based, according to the authors, the maximum train load which an engine can haul in good weather; to rate, on the other hand, the capabilities of an engine in all sorts of weather, and especially in winter time, no greater co-efficient than $\frac{1}{6}$ should be counted upon. In the same tables a superior co-efficient than $\frac{1}{5}$ is noted down also, but this occurred while starting at a station, a case where the limit of adhesion—by the exertion of an instantaneous effort—is always closely approached. I may mention that the co-efficient of adhesion is sometimes quoted as a kind of "figure of merit," in comparing the useful effect of different engines working different lines; but if the train resistances are not precisely known, and "guessed at" only, this manner of rating is very apt to mislead. During the above

trials, however, the tractive force was registered constantly by the traction dynamometer; the power absorbed in moving the engine having also been ascertained previously in a similar manner, the total tangential effort, or the gripping friction between tyre and rail, corresponding to a certain fraction of the adhesive weight, was thus correctly known.

On mountain lines, locomotives are generally worked up to their maximum adhesive power, hence frequent slipping. On the Semmering an adhesion from $\frac{1}{8}$ to $\frac{1}{7}$—a very favorable figure, considering all the circumstances—is usually maintained, whereas on the Giovi the ruling coefficient amounts to but $\frac{1}{10}$. It is thus evident that in a well-proportioned mountain engine, the ratio between "cylinder power" and adhesive weight may differ widely from what experience has established in ordinary practice.

Proceeding now to the actual working of the great mountain railways in the Alps and the Apennines, I shall not attempt to establish a comparison between the results and the useful effect obtained with various types of engines; to do this without prejudice, many elements—besides the configuration of the line—would have to be known and taken account of, such as the state of the rails, the construction of the rolling-stock, the intensity and direction of the wind, the surface of the wagons, the length of trains, the dimensions of bearings and of wheels, the wheel bases, the nature of lubrification, the temperature, the mode of coupling, the manner of loading, or the proportion of net to gross load, etc. What I intend recording, with reference to engine performances, comprises simply some personal observations, aided by the information of railroad superintendents, running shed foremen, and engine drivers.

1. The Semmering, although preceded by the working of steep gradients on American railways, and by valuable experience gained in the Fichtelgebirge, may truly be termed the Rainhill of mountain railways. True, there was no gallant George Stephenson, but there a glorious edifice was built on his foundation-stone, and followed since by works of still greater magnitude. On the mountain passes of those majestic Alps, where once great warriors of by-gone ages led on their armies, are now fighting the modern Hannibals, the Charlemagnes, and Napoleons, leaving their footprints in the everlasting rock! It would occupy too much of your space, sir, were I to draw a historical outline of the Semmering contest in 1851, but those of your readers who feel interested on this subject may find ample and impartial information in "Engineering," vol. i., p. 57, and specially in a memoir by M. Fouche, entitled: "Des progrés des machines locomotives et de leur influence sur les conditions de l'établissement des chemins de fer." Paris, 1852. The period, following the opening of the Semmering up to the present date, occupies likewise a conspicuous place in locomotive history. Up to 1868, the heavy goods trains were always divided into several portions at the foot of the incline; each portion was taken over the mountain by a single engine, the employment of two engines having not been found advisable. In the spring of 1868 a serious accident occurred on the gradient, owing to the breakage of a coupling; it thus happened that a portion of the leading goods train fell back upon another train, following at a short distance. This occurrence led ultimately to the application of "double traction" in the shape of a "head" and a "tail" engine, as now introduced on nearly all mountain lines; and this system, having undergone a serious trial over the reverse curves of the Semmering, has given up to the present every satisfaction. The new Semmering engines are fitted with Le Chatelier's counter-pressure steam brake, and with screw reversing gear. The Semmering is situated in the Styrian Alps, and is traversed by the railway connecting Vienna with Trieste, on the Adriatic Sea. The mountain section of the line is 26 miles in length, the average rise being 1 in 47, and the maximum inclination 1 in 40; the smallest curves are of a minimum radius of 9 chains, but this limit is not attained on the steepest gradients. In 1868 the total cost of "traction" on the Semmering was 1s. 9½d. per train mile, *vide* "Mémoires et compte rendu des travaux de la Société des Ingénieurs Civils, 2e trimestre, page 300."

2. The Brenner line in the Tyrol, which was opened in 1867, unites the northern and southern sections of the Tyrolean line on the South-Austrian Rail-

ways, forming thus a very important connecting link between South-Eastern Germany and the railway system of the Alta Italia. The mountain railway over the Brenner Pass is 78 miles in length ; there are long gradients of 1 in 40, and frequent curves of 14 inches radius. The Brenner is worked similarly to the Semmering, but the cost of traction is somewhat higher, on account of the price of combustibles. On both lines various sorts of lignite are consumed ; in the Semmering engines two sorts of lignite are burnt—Leoben lignite, having 65 per cent., and Styrian lignite, having 57 per cent. of the calorific power of coke from Witkowitz, which latter is about equal to ordinary English coals. The price of a ton of fuel, and equivalent to the heating power of a ton of coke, averages on the main line of the South-Austrian 16s., and in the Tyrol 33s. 8d. sterling. In 1868 the consumption of fuel in a Semmering engine was 84½ lbs. per train mile, and 60½ lbs. in a Brenner engine, the corresponding train loads being on the average 125 tons and 100 tons (goods and passenger trains). The security with which this difficult line has been worked since its opening is attributed chiefly to the system of "double-traction" with a head and a tail engine, coupled with the employment of Le Chatelier's steam brake. On several occasions the use of this apparatus, combined with the ordinary brakes, has enabled the engine-drivers to pull up within a distance of 300 yards, the train descending on a gradient of 1 in 40 at a speed of ten miles per hour.

3. The Poretta inclines, so called after the town of Poretta, situated on the northern slopes of the Apennines, connect Bologna with Pistoia, from which latter point the line branches off to Pisa and Leghorn to the right, and to Florence to the left hand. The distance between Poretta and Pistoia is 26 miles, over continuous gradients of 1 in 40. The summit of the line is at Pracchia, 10 miles from Poretta, and immediately after leaving the station of Pracchia the long Apennine tunnel is passed. There are altogether 47 tunnels over the 26 miles of railway, and frequent curves of 15 chains radius. One of the longer tunnels presents actually the development of a screw ; on leaving this remarkable tunnel on the top, the entrance hole can be seen down the precipice almost perpendicularly beneath. The Poretta is now being worked by the ordinary six-wheel coupled goods engines of the company. These engines—after the pattern of the Paris-Lyons goods engines—are fitted with various exhaust gear, screw reversing arrangement, and Le Chatelier's brake. The reversing screw is of steel, 2 in. in diameter, $1\frac{3}{4}$ in. pitch, supported by a wrought-iron chair bolted on to the footplate ; the nut is of case-hardened iron, 5 in. long, and the whole arrangement is altogether a very neat and efficient one. The Le Chatelier apparatus is fixed close to the reversing gear, so that both can be worked together with great facility. In applying the counter-pressure steam brake, the link motion is first of all put on mid-gear, and the regulator kept closed ; the injection apparatus is then so regulated that a thin cloud of steam may be seen over the chimney top; the regulator is then fully thrown open, and the link motion gradually reversed from mid to back gear, according to the retarding power required. In the goods engines the injection takes place in the blast pipe, while in the mixed engines, working on the main line, the apparatus injects in the exhaust ports underneath the slide valves ; in neither case, however, the steam valve of the apparatus is made much use of. The maximum hauling power of the Poretta engines is a train load of about 110 tons. The express is drawn by one engine, while in the case of the mixed and goods trains two engines are employed ; in the former case both engines are coupled together in front of the trains, the front end of the second engine being next the hind end of the first engine tender. The goods trains are "drawn" by one engine and "pushed" by another, but the type of engine is the same for all trains. I must not forget to mention that the section from Bologna and Pistoia is constructed and worked as a "single line," and that the inconveniences caused by the working of the engines through the narrow tunnels are very great, and at times even alarming. In making an ascent with a mixed train, and having selected the footplate of the second engine as my "observatory," I was practically convinced that the limit of respiration was nearly as well attained as was, in fact, the limit of adhesion.

Name of Railway.	Section of Line.	Maximum Inclination.	Minimum Radius of Curves on Steepest Gradients, in Chains.	Type of Engine.	Diameter of Cylinder in inches.	Stroke, in inches.	Diameter of Wheels, in inches.	Boiler pressure, in pounds.	Heating Surface in square feet. Firebox.	Heating Surface in square feet. Tubes.	Heating Surface in square feet. Total.	Working weight of Engine, in tons.	Weight of Tender at Starting, in tons.	Total weight at Starting, in tons.	Adhesive weight, in tons.	Maximum Train Load excl. Engine in Summer, in tons.	Speed on Mounting Gradients, in miles per hour.
South-Austrian	Semmering	1 in 40	20	Eight wheels, coupled, with tender (modified Engerth)	18¾	24	43	140	75	1570	1645	46¾	19¾	66	46¾	175	10
	Brenner	1 in 40	20	Eight wheels, coupled, with tender, system, Hall	19 11–16	24	42½	135	102	1850	1952	47	20	67	47	175	11
	Poretta	1 in 40	14	Eight wheels, coupled, with tender, system, Hall	19 11–16	24	42½	135	102	1850	1952	47	20	67	47	150	11
Alta Italia	Giovi	1 in 40	15	Six wheels, coupled, with tender	17¾	25⅝	51½	120	80	1267	1347	84	20	54	34	110	12
		1 in 28½	20	Four wheels, coupled, twin engine	14	22	41¾	105	150	398	548	54		54	54	120	11
		1 in 28½	20	Six wheels, coupled, twin engine	16	22	48	115	157	2005	2162	66	..	66	66	140	11
		1 in 28½	20	Eight wheels coupled, system, Beugniot	23⅝	24	47¼	135	102	1915	2017	51	18	69	51	120	11
Swiss Central	Hauenstein	1 in 37	18	Six wheels coupled, system, Engerth	17⅞	24	45¾	105	68	1210	1278	36	14	50	36	93	15
		1 in 37	18	Six wheels coupled, tank engine	17⅞	24	45¾	120	74	936	1010	40	..	40	40	93	15

4 The Giovi gradient in the Apennines, although only 6¼ miles in length, presents, of all the preceding mountain railways, the greatest difficulties and the greatest obstacles to a regular working. The ascent of the mountain begins close to Genoa, till the station of Busalla is reached, from where the line falls off, over light gradients, to the town of Novi, 34 miles from Genoa. Like the Poretta, this section comprises an uninterrupted succession of gigantic works of construction. The Giovi gradient begins at Pontedecimo, 8½ miles from Genoa, and rises at the mean rate of 1 in 38 up to Busalla. The various gradients on the Giovi being composed of a stretch of 1 in 50, then 1 in 36, then comes a very short stretch of 1 in 28½, and finally, through a tunnel of 3,280 yards in length, 1 in 34½. At Pontedecimo, where there is quite an array of mountain locomotives, are now stationed sixteen six-wheeled coupled twin engines, twelve four-wheel coupled twin engines, and ten Beugniot engines. The passenger trains are taken over the Giovi by a Beugniot engine, for the mixed train a twin engine is usually added in the rear of the train, and the goods trains are hauled by two twin engines, one working in front and the other behind the train. To illustrate the nature of daily working on this remarkable line, I will cite the experience with a mixed train on the 19th of November last. The train was composed of eight passenger carriages and of ten goods wagons, making a gross load of 164 tons. To haul this train from Pontedecimo to Busalla, not less than 105 tons of adhesive engine weight were taken into requisition, viz., a Beugniot engine, weighing 69 tons (51 tons adhesive) in working trim, and a 54 tons twin engine. Including engines, the total weight of the train was consequently 287 tons, and, "guessing" the total resistances at 80 lbs. per ton, the corresponding tractive power would be 10½ tons, or one-tenth of the adhesive weight under the engine wheels. The weather was rather misty, but the rails seemed to be in a normal condition. The Beugniot engine, leading the train, slipped terribly, with the safety valves blowing off at 135 lbs. to the square inch; in fact, the engine could only be got to "bite" by an energetic application of the sand-box. The twin-engine in the rear of the train—and working, therefore, under

more favorable conditions—kept on pushing very steadily. The ascent was made in 37 min., or at a speed of 10 miles per hour. The Giovi and the Poretta are on the very extensive railway system of the Alta Italia, this company working now 1,640 miles of railway, embracing the lines of the Piedmont, Lombardy, Venetia, Emilia, Liguria, and the lines on the right-hand bank of the river Arno. The Alta Italia and the South-Austrian railways belong to a French company.

5. The Hauenstein line, on the Swiss Central Railway, traverses between Bale and Olten, a very picturesque mountain range, called the Jura Alps, which attain at the Weissenstein, near Soleure, a height of 4,000 ft. above the sea level. The distance between Bale and Olten is 24½ miles, worked in two sections, Bale-Sissach, rising at the rate of 1 in 100, and Sissach-Olten, having a maximum inclination of 1 in 37; shortly before reaching Olten, the great Hauenstein tunnel is passed on a gradient of 1 in 38. There are frequent curves of 18 chains radius. The passenger trains averaging 85 tons, are worked by a passenger engine between Bale and Sissach, and by a six-wheel coupled goods engine from Sissach to Olten; the mixed and goods trains of an average weight of 160 tons, are worked by two goods engines over this latter portion of the line. The goods engines employed are six-wheel coupled Engerth engines, and six-wheel coupled tank engines; their adhesive weight is 36 tons and 40 tons respectively, and their maximum hauling power in good weather about 93 tons each, over the most difficult sections of the line. The ruling coefficient of adhesion on the Hauenstein is about $\frac{1}{8}$, this being limited by the damp tunnel near Olten.

The foregoing notes concerning the service of traction on the mountain sections of the South Austrian, the Alta Italia, and the Swiss Central railways, are recapitulated in the annexed table.

MACHINE BEARINGS.

From "The American Artisan."

The great bugbear in machinery is friction. It is this that involves expense for lubricants, that causes the ultimate wearing out of the machine by the gradual destruction of its working surfaces, and that lays a constant tax in the shape of driving power not utilized in productive work. Although friction is by no means confined to the journals of mechanism, it is with these that its detrimental results are the most evident, and the means of alleviating it the most easily applied. Such alleviation is provided through the agencies of proper construction of the bearing and journal, the use of some interposed material offering less obstruction to the moving contact than is afforded by the surfaces themselves; and a suitable velocity of the journal as compared with that of the parts driven thereby—this last, of course, having more special application to lines of shafting.

As to the first of the above-mentioned essentials—the construction of the bearings and journals—it is well known that the friction between two different metals, as, for example, iron upon brass, is much less than that of a single metal upon itself, for instance, iron upon iron, and hence the now universal use of the Babbitt, type, and gun metals for journals. Aside from this, the length of the bearing in proportion to its diameter has much to do with its economical results; Fairbairn having demonstrated that with wrought-iron the length of the bearing should be 1¾ of the diameter of the journal. Both the length and diameter, moreover, must bear some relation to the pressure. The authority above cited lays down the rule that in flywheel, and similar shafts the pressure on the journal should never exceed 180 lbs. to the sq. in. In this connection may also be noted a very important point having reference to the resisting power of journals to tension and strain. As commonly made, with the shoulders turned down to a sharp angle, they lose one-fifth of their strength, which may, and always should be, avoided by making the corners, viewed from one side, rounded instead of sharp.

With regard to lubricating materials,

sperm oil has long been considered the best; but the lubricating material must, in a measure, be varied according to circumstances. With unguents, like lard or tallow mixed with oils, less useful results are obtained on metal than upon wood bearings. This is commonly ascribed to the adhesive and consequently resisting action of the somewhat viscous substance, and the effect of which has a certain ratio to the extent of the surface upon which it acts. Rennie's experiments with journals under pressures varying from 1 to 5 cwt. showed that with tallow and certain anti-attrition compounds the friction reached its minimum, while it rapidly increased with hog's lard and various kinds of oils. Under greater pressure, however, for instance, mill steps bearing a weight of 280 lbs. to the square inch, which it is difficult to keep properly lubricated, the finest and most limpid lubricating oils are recommended. Uniformity in the supply of the lubricant is also a matter of much consequence—too much involves waste and does only slight good, while too little, of course, does harm. It would be better than the present practice of intermittent oiling, if self-lubricating devices were universally provided upon journal-boxes, although it must be acknowledged that few or none of the scores of such apparatus that have been made, fully serve the useful purpose for which they were designed. As to the velocity of journals in motion, we need here notice only the conclusion of Fairbairn: that thereby will be a saving of from 30 to 60 per cent. in weight (and, of course, in friction) as compared with that involved in the slow motion once in vogue, and a large percentage of power formerly lost in the machinery of transmission will be utilized in the actual work in the machine to which the power is transmitted.

TELEGRAPHIC BATTERIES AND CONDUCTORS.*

Static or frictional electricity has long since been discarded as an agent in the electrical instrumentalities for communicating at a distance. All attempts hitherto to make it practicable have failed, and all the devices for that purpose, however ingenious, as most of them were, must be consigned to the category of failures. The principal form of electricity, which has been effective, either in the semaphore or in the telegraph, is dynamic electricity, usually generated by the chemical action of acids upon metals, or the decomposition of metallic salts. The earliest form of Voltaic battery, even the first column of Volta, is available to produce the actual result required, either of showing a signal, as in the semaphore, or making a record, as in the telegraph. The earliest form employed by Morse, in 1835, and with success so far as to show the practicability of recording, was the well-known Cruikshanks battery. Since this early period many modifications and substantial improvements in the battery have been made, and the constant batteries of Daniel, of Grove, and of Smee, in England, and of others on the European continent, have have given greater facility in operating the instruments both of the telegraph and semaphore. But the introduction of magneto-electricity, one of the grand results of the generic discovery of Oersted, and of the more recent discoveries of Faraday, has furnished the means of constructing a new generator of electricity, which takes its place intermediately between the frictional and the Voltaic, having less quantity than the Voltaic and less uncontrollable intensity than the frictional instruments. The Voltaic, however, has the quality of giving more readily a continuous current, and is therefore better adapted to recording in all the instruments using the Morse code.

* From the Report of Prof. S. F. B. Morse, LL.D., U. S. Commissioner to the Paris Exposition.

FARMER'S THERMO-ELECTRIC BATTERY.

The batteries exhibited have little of originality. With one or two exceptions, they generally show unimportant modifications of those long known.

The thermo-electric battery of Farmer, of Boston, is one of novel construction, and deserving of special notice.

It consists of three rings of nine pairs each. A common rubber tube conveys ordinary street gas to a gas burner or gas

stove under the centre of the battery. A deflector is placed at the top to keep the heat down in the centre. All that is required to put the battery in operation is to turn on the gas and light at the burner. The battery acquires its maximum activity in a few moments, when it works continuously and constantly as long as it receives heat.

These batteries are made of various sizes, weighing from a few pounds to half a ton. One of this larger class is now in operation, and is capable of depositing about one pound of copper per hour, at an expense of five or six pounds of coal in the same time.

The smaller batteries are more conveniently operated by gas or lamp. These latter are very convenient for medical use or for telegraph local batteries. The somewhat larger battery gives all the effects of a series of cells (of the acid batteries in common use).

These batteries are admirably suited to the wants of the exact experimenter, and render the most useful assistance in their investigations where an absolutely constant current is required, being capable of working for an indefinite period without a perceptible variation in the strength of current which they deliver. Their utility is very apparent to the electrotyper who desires a uniform current, and to the electro-gilder and silver-plater they are especially commended, because they require no acids, mercury, or liquids of any kind in their operation.

The saving which they effect in time, attention, waste, their cleanliness, the readiness with which they can be put into operation, the small expense of working them, and their durability, commend them to all.

Where an establishment is doing sufficient work to require the use of one of such size as can be operated by coal as a fuel, the economical production of electricity by their use is very obvious, five or six pounds of coal being capable of evolving as much electricity as one and a half pound of zinc, five or six pounds of sulphuric acid, and one ounce of mercury.

These batteries, like any series of cells, can be coupled to suit the work they have to perform. As compared with the acid batteries, these batteries have been worked with Boston gas as follows: 10 pairs equal to 1 Smee cell in power; 24 pairs equal to 1 Daniel cell in power; 44 pairs equal to 1 Grove cell in power. But in calculating for a battery to perform work for an indefinite period, an addition of 50 per cent. upon the above list is recommended, as the heating power of gas differs very materially in different places. Naphtha has been used with perfect success, and found very economical.

The principal objects kept in view in this invention are, first, to make a battery of sufficient power to be available for industrial uses; second, that it should be reasonably durable; third, that it should be convenient to use; fourth, that it should not be too costly.

With regard to the first object, one has been constructed and used which has deposited 12 lbs. of copper, from a sulphate of copper solution, in 24 hours, by the consumption of less than 110 lbs. of anthracite coal. Smaller ones have been constructed that are most conveniently operated by a gas flame, and which will evolve 50,000 ft.-lbs. of electricity by the consumption of 1 lb. of common coal gas.

These latter are made of various sizes, and capable of evolving from 20 to 300 ft.-lbs.. of electricity per minute. A common pint cup Grove cell will evolve 80 ft.-lbs. of electricity per minute. The current from this (gas-consuming) thermo battery is the most constant and uniform of any that I have ever used, and is admirably adapted to the requirements of exact research.

With regard to the second head, the durability of the thermo battery depends much on the temperature at which it is worked. At all temperatures there appears to be a gradual increase in the specific resistance of the alloys which enter into its composition, but the more slowly the lower the temperature of the heated junction. One of about 150 ft.-lbs. per minute power has been in nightly use for nearly a year. Its power has not been recently measured, but it is still in working order. Some have been in almost daily use by physicians for nearly two years.

Third. The gas-consuming batteries are as convenient as need be, requiring only to be attached by a flexible or other pipe to a gas burner. The large battery fired with coal needed attention every 3 or 4 hours.

Fourth. The thermo battery is much more costly than an acid battery of equivalent power, in the first instance; but the cost of daily maintenance is less. A thermo battery, equivalent in power to 4 or 5 Grove cells, costs about $90.

A thermo battery, to be heated by waste steam, could be operated at trifling cost, and would be very durable, but the amount required to do a given amount of work with only 120 deg. difference of temperature between the junctions, might be of inconvenient size and first cost.

In this battery the two elements used are, German silver for the negative pole, and an alloy of zinc and antimony for the positive pole. The proportions of the zinc and antimony used are, about 96 parts antimony and 53 parts zinc, as mixed in the melting pot. The pairs are arranged around a central source of heat; and the outer junctions are cooled by radiation and connection.

LECLANCHE'S BATTERY.

This batttery is much in use in the French telegraph administration. It consists of a prism of carbon for its positive pole, which is surrounded by a mixture of peroxide of manganese and carbon pulverized, filling the porous jar. This jar is put into the glass jar containing a solution of sal ammoniac; within the same glass jar and solution is a prism of amalgamated zinc, forming the negative pole. Its action is thus: On closing the circuit, the sal ammoniac is decomposed, the chlorine of the solution is absorbed by the zinc, the negative pole; while the hydrogen and the ammoniac pass to the positive pole, reducing the peroxide of manganese. According to the inventor's explanation, "the peroxide of manganese mixed with carbon being a good conductor of electricity, the system may be considered as a single fluid element, in which the positive pole is formed of an artificial metal having a great affinity for hydrogen."

MAGNETO-ELECTRIC BATTERY OF S. HJORTH.

This invention by S. Hjorth, of Copenhagen, relates to improvements introduced into the construction of magneto-electric batteries, with a view to obtaining by a slow motion of the armatures any required quantity or intensity of electric fluid.

The improved battery may be constructed of different circles of bar magnets, set partly around and partly above each other, with corresponding intermediate armatures mounted on wooden or other suitable disks on a central shaft, made to rotate by suitable mechanism.

When quantity of the electric fluid is required, the currents are collected by rings, and from thence pass by conductors to a commutator mounted at the upper end of the central shaft. When intencity is desired, the conductors may be connected in one length according to circumstances.

The armatures are provided with false poles, the dimensions of which correspond with those of a certain number of magnets of similar polarity; say for instance 8 or 9 bars. The changes of polarity in the armatures at each revolution will consequently be equal to the number of these armatures multiplied by the respective series of magnets of similar polarity.

The power developed being in ratio with the number of changes of polarity produced at each revolution, an advantage may be obtained by the application of equal numbers of armatures and magnets. This arrangement is composed of 3 disks, each provided with 96 armatures, corresponding with the same number of magnetic bars, so that each revolution gives rise to changes of polarity equal to

$$96 \times 96 = 9{,}216 \times 3 = 27{,}648.$$

The armatures are coiled with wire internally and externally. The two intermediate circles of permanent magnets are fixed to brass rings.

The armature wheel or disk is formed of hard wood or other suitable material, and is provided with two rings, composed of vertical bars overlapping each other, in which the armatures are geared.

It is evident that the concentric series of magnets and armatures, as also the number of these elements, may be increased or decreased according to the effect to be produced. In all cases, the armature disks should be arranged "stepways," so that when the armatures of the first series have completely passed between the magnets, those of the following series reach but half way, and those of the third series only commence to be drawn in between the magnets. The force of

attraction being thus added to the power applied to the central shaft, the motion of the latter is necessarily facilitated by increase in the power of the magnets.

The form, dimensions, and general details of construction of the apparatus above described may be varied according to its intended application.

LADD'S DYNAMO-ELECTRIC APPARATUS.

This apparatus is not in the catalogue, but was exhibited in the English department.

A French journalist thus enthusiastically speaks of it:

"In the judgment of all competent persons, the most astonishing object in the galleries of the Champ de Mars is the machine of Mr. Ladd, constructor of physical instruments, of London, exhibited under the name of Dynamo-Electric Apparatus. Very extraordinary in its principle, in its construction, and in its action, it is composed essentially of two plates of soft iron about 2 ft. long, 1 ft. wide, and 4 in. thick, kept at a distance of a few inches from each other. They are both of them attached by their ends to two kinds of cylindrical surfaces, also of soft iron, in the bosom or hollow of which turn two armatures of Siemens' cylinders, of soft iron, grooved upon their two faces and covered according to their length by insulated copper wire. An insulated copper wire sufficiently large surrounds also the two plates in compacted spirals perpendicular to their length, and going from one plate to the other, so as to form a closed circuit. The current pervades it through a commutator designed to maintain it always in the same direction. The second armature, on the contrary, is entirely out of the circuit of the first armature and of the plates of soft iron. It turns simply opposite the second poles of the plates, and becomes the seat of an induction current always in the same direction, which, conducted by the wires soldered to the two poles, goes to produce outside the effects of light, of heat, of motion, of affinity, or of chemical decomposition, as may be desired.

"It is perceived that in itself this whole mass of soft iron, of copper wires, without steel, without magnets, is absolutely inert. How can life and activity be given to it? By providing it with a small quantity of magnetism, by priming it magnetically. It is sufficient for this strictly to place properly the plates by putting them in the magnetic meridian, so that the terrestrial magnetism may communicate to it a slight magnetism. But it is better to make to pass once, and once for all, through the wire which surrounds the plates, the current from a Daniels', Smee's, or Bunsen's battery, which, after having made them temporarily electro-magnets, leaves them, the circuit being broken, with a little of residual magnetism, which magnetism for the future (and if they are not left too long to themselves) renders them always ready for action, or to create torrents of electricity of which they become the source. We have thus passed from absolute inertia to static or powerful activity. Motion completes all the rest. It is sufficient, in fact, to turn at the same time the two armatures, so that in returning constantly upon itself, the inductive current engendered at first by the residual magnetism incessantly increases the polarity or the activity of the plates, which have become powerful electro-magnets, and so that the second armature becomes the point of departure of an electric current of quantity and intensity proportional to the rapidity of rotation of the armatures, or to the force expended by the operator. With the machine exhibited, of which we have given the dimension so small, the exterior current is equivalent to that of 25 or 30 Bunsen elements.

"It supplies a Foucault regulator of medium size, and maintains at a white heat a platinum wire of more than a yard in length and half a millimetre in diameter. Here then is the immediate transformation, from the only condition, a small quantity of residual magnetism, by means of mechanical motion, first of power, next of electric effects, then luminous, calorific, and chemical, etc. Nothing in fact is more simple, more effective. Nothing also is more grand, more unexpected, more mysterious. Mr. Ladd has borrowed from Mr. Wyld his plates, leaving out the magneto-electrical apparatus, substituting for it simply the residual magnetism, and adding a second armature, which is the new element of his invention. He has taken from Messrs. Wheatstone and Siemens their return of the current upon itself, forcing it thus to increase itself, constantly multiplying it-

self, and like them rejecting the battery, for which there is no necessity."

If others do not go quite so far as this earnest French writer in designating the apparatus of Mr. Ladd as "the most astonishing object" in the whole Exposition, they will certainly agree with him in his admiration of the *effects* of this beautiful instrument, and in his designation of them as "grand, unexpected, and mysterious." Mr. Ladd is stated to have borrowed from Messrs. Wheatstone and Siemens their method of causing the current to return upon itself.

An account is given of this discovery from the pen of the discoverer, the eminent Dr. Werner Siemens, of Berlin, who seems to have observed this effect, and utilized it, apparently concurrently with Professor Wheatstone, but in reality a little before him, as will be seen by the following letter addressed to Professor Morse :

"BERLIN, *December* 30, 1867.

"Herewith I send you the translation of my communication to the Academy of Sciences in Berlin. I have had it done in London, for we are very weak in English here. As you see by the date of the communication, the publication took place about one and a half month sooner than my brother's and Mr. Wheatstone's speech in London. Already, in November of last year, my first machine was in working and made known to the scientific men here. Wheatstone added something new to it. Ladd has the merit of having shown a larger machine than that in operation in Paris. I had not enough machine power in the Prussian department, and on that account did not take a very large machine with two cylinders, like Ladd's. If you should visit Berlin on your return journey (which I hope), I can show you this machine, which gives a brilliant electric light and produces ten cubic centimetres of oxygen and hydrogen gas per second. I could also show you other interesting apparatus. A new mechanical tachygrapher for Morse writing, and an electric distance measurer. This would be especially useful to steamships, as with them we can measure the exact distance of steamers, light-houses, coasts, etc., while in motion."

"*On the conversion of mechanical effect into electric current without the employment of permanent magnets.*—When two parallel wires forming part of the circuit of a galvanic battery are approached to or separated from each other, a diminution or augmentation of the strength of current in the whole circuit is observed, according as the movement is in the direct or the inverse direction of the forces which the currents in two wires exercise reciprocally upon each other.

"The same phenomenon is observable still more remarkably when the poles of two electro-magnets, whose wires form parts of the same galvanic circuit, are made to approach or recede from each other. If the direction of the current in one of the wires is changed at the moment of their greatest or least distance, as is the case in all electro-dynamic rotating apparatus, a lasting diminution of the current occurs as soon as the apparatus is put into motion. This diminution of the current of the battery by opposite induction current it is which renders it impossible to employ galvanic electricity successfully as a motive for the production of mechanical effects. Suppose such a machine to be turned backward by some foreign force, it is evident that these induction currents must add themselves to that of the battery, which they proportionally strengthen; and since an increase of this circuit current is necessarily followed by an increase of magnetism in the soft-iron cores, and then again by a further corresponding increase of currents, and so on, the accumulation very soon reaches a point at which the galvanic battery may be removed from the circuit without occasioning any perceptible diminution in the resulting current. The moment the rotation is interrupted, however, the current ceases and the magnetism vanishes. Sufficient magnetism remains, nevertheless, in the iron to cause the process of accumulation to recommence from the moment that the rotation is renewed. It is only necessary, therefore, to magnetize the iron once by a galvanic current of short duration in order to render it forever afterwards capable of being recalled into action by simple rotation.

"The direction of the current depends upon the polarization of the residuary magnetism; and it can only be changed when, by means of a galvanic current, the residuary magnetism of the iron is changed.

"The effects here described take place

also with every electro-magnetic machine whose movements depend upon the attraction and repulsion of electro-magnets whose wires form a single circuit. Nevertheless, in order to provide apparatus especially for showing powerfully the phenomena of the dynamo element, a particular construction is found to give the best results. The wire of the stationary electro magnet must have a sufficient magnetic inertia, so that the strength of the attained magnetism does not diminish during the reversing of the current in the wire of the rotating armature. It is also essential that the armature should be so constructed that during its rotation the opposite polar faces of the electro-magnet should be always magnetically closed. These conditions are best fulfilled by the employment of the band form of armature proposed by me some years ago, and which has since then come very generally into use. The armature in question consists of a cylinder of soft iron rotating upon its axis. It carries an insulated wire wound in two deep longitudinal grooves, one in each side. The poles of a battery of permanent magnets, or, in this case, those of the stationary electro-magnet, are cut out so as to let the armature rotate with the least possible space between them.

"By means of a machine constructed upon this principle, if the proportions of the various component parts are justly determined and the commutator properly placed, and a sufficient velocity of rotation given to the barrel armature, a current may be produced in the wire which is so intense that it develops heat enough to burn the covering with which the wire is insulated. This accident, however, can be avoided, when the machine is required to be kept in constant action, by the introduction of resistances or by moderating the velocity of rotation.

"Magneto-electro inductors do not increase in power proportionally with an increase of dimensions, whereas with the machine in question the reverse is the case. The reason of this is that in permanent magnets the magnetism increases in a very small ratio to the weight of metal of which they are made, and that with a battery of permanent magnets it is impossible to concentrate their action upon a limited surface without their mutually diminishing their strength to a very material extent. On this account, steel magnets are not well adapted for employment in magnet inductors which are required to produce very strong currents. It is true that such machines have been made with permanent magnets, which have given an intense electric light, but, in order to attain this, they were required to be of colossal dimensions, and were correspondingly expensive. In addition to this, the magnets lost very soon the major part of their magnetism, and the machine therefore its force.

"Mr. Wyld, of Birmingham, has lately constructed a machine for the production of powerful magneto-electric currents, whose capability he has increased by the employment of two barrel inductors of my construction, as described above. In the larger of the two he has substituted an electro-magnet for the battery of permanent magnets, setting it in action by the current of the smaller one, and as the electro-magnet becomes more strongly magnetic than permanent magnets could, the resulting current is correspondingly stronger.

"It is easily seen that Wyld has, by this construction, considerably obviated the difficulties found in employing steel magnets. But independently of the inconvenience attending the use of two inductors, his apparatus has still the disadvantage that it is directly dependent upon the steel magnets of the first inductor for the efficiency of its operations."

SULPHATE OF MAGNESIA BATTERY.

A new battery is described by Mr. McGowan, general superintendent of telegraphs in Victoria, Australia, as producing an economy over the sulphate of copper battery, used for the local battery to work the register.

This form is known as the sulphate of magnesia battery, and has been patented. "The containing cell is of more than ordinarily large dimensions; the negative and positive elements are copper and zinc, cylindrical in form, and the exciting fluids are: 1, sulphate of magnesia, in the form of a nearly saturated solution; 2, sulphate of copper in broken crystals. The former surrounding the metals in the containing vessel; the latter in partial solution, admitted through a perforation at the extremity of a conical glass receiver, placed within the interior cylinder."

SUBMARINE TELEGRAPH CABLES.

In consequence of the success which has attended the use of submarine telegraph cables, and especially the great success of the Atlantic cable enterprise, the attention of the skilful has of late been turned to the importance of improving and perfecting them.

There were many electrical experiments made with submarine conductors for various scientific purposes previous to their application to telegraphy.

It is believed that the first submarine telegraph line was laid and operated in New York harbor by Morse, in October, 1842. Although destroyed early after its submersion, by the anchor of a vessel getting under way, it was not destroyed until the fact of its ability to transmit despatches was fully demonstrated. The gold medal of the American Institute was bestowed for this success.

Since that date the skill of European, especially of English, French, and Prussian savans, has succeeded not only in improving the construction of submarine cables, but in extending them in various directions from the United Kingdom across rivers, straits, and channels, and through seas, until the islands and continents of the eastern hemisphere are to a great extent telegraphically united, and the great enterprise of the day, the Atlantic telegraph, through the skill and perseverance and capital of English and Americans, has been the overcoming of the apparently insurmountable obstacle of an ocean deemed until recently unfathomable. It is unnecessary here more than to allude to this well-known enterprise, since the exhaustive history of it is familiar to all who have read the history of the Atlantic telegraph in the graphic pages of Doctor Russell and the Reverend Henry Field.

COMPOUND TELEGRAPH WIRE.

As directly connected with the improvement of submarine cables, attention is drawn to the "compound telegraph wire," the invention of Moses G. Farmer, Esq., of Boston, who exhibited the thermo-electric battery, already described.

Mr. Farmer, in a letter to Professor Morse, dated Boston, July 29, 1868, thus describes this valuable improvement, and the tests to which it has been subjected:

"I sent to you, a little time since, a pamphlet relating to our new compound telegraph wire, composed of a steel core and a copper covering, the whole coated with an alloy, principally tin, for preservative purposes. You will take in at a glance the numerous advantages of this wire.

"As has been most fully shown by Thomson's researches, and amply demonstrated by the working of the Atlantic cable, the speed at which a line can be worked is directly as its conductivity, and inversely as its electro-static capacity. The distance, also, which can be reached is directly as the conductivity, and as the degree of insulation. Anything, therefore, which improves the conductivity, or diminishes the static capacity, or increases the insulation, is a benefit.

"Let us look for a moment at the comparative conductivity, strength, and specific weight of iron, steel, and copper. I have carefully measured and recorded one or all of these elements for more than fifty samples in common use. I find upon an average that from $2\frac{3}{4}$ to 3 miles of common telegraph iron wire would break of its own weight if suspended vertically; about $1\frac{3}{4}$ miles of copper, and about $7\frac{1}{2}$ miles of the steel which we use. I copy my coefficients:

Steel	7.47	$\left(\frac{T l}{w}\right)$
Galvanized iron	2.91	
Copper	1.72	

"Now, for weight per mile, take the diameter of the wire in inches, and multiply its square by—

For steel	13373.	$\left(\frac{w}{d^2}\right)$
Fir iron	13800.	
For copper	15400.	

"The result will be the weight per mile, 5,280 ft.

"Now, for conductivity, assume as unity a round wire of chemically pure copper, $\frac{1}{10}$ in. in diameter; it would weigh $39\frac{1}{3}$ lbs. per mile. I will copy my latest coefficients, which, if multiplied by the weight per mile, will give the actual conductivity in terms of the unit above assumed, viz.:

$$\left(\frac{c\,l}{w}\right)$$

For steel	.00262.
For copper	.02045.
For galvanized iron	.00355.

"The coefficient for copper, .02045, is one for commercial copper, which I used in making up the tables in the pamphlet

referred to. We now use a copper, for which the proper coefficient is, .02301, or 90 per cent. of pure copper (which would be .02556).

"The resistance of 5,280 ft. of pure copper wire, weighing 39.11 lbs., would be about 21.3 B. A. units.

"Now, with the help of these coefficients, let us examine 2 or 3 wires. No. 8 iron wire weighs 375 lbs. per mile. (*Vide* Shaffner, L. Clark, M. G. Farmer.) Hence its tensile strength, or the weight which would break a short length of it, would be T=2.9×375=1087 pounds, and its conductivity would be C=.00355×375 =1.331—Farmer's latest; (C=1.298, L. Clark). This refers to ordinary galvanized iron wire, at about 10 or 10½ cents per pound, and not Washburn's best at 14 cents.

"Now, take 56 lbs. per mile of steel:

Its T = 7.47 × 56 = 418.
Its C = .00262 × 56 = 1467.

"Take, now, 56 lbs. of copper per mile, and we have:

Its T = 1.72 × 56 = 96.
Its C = .02045 × 56 = 1.145.
Or its C = .02301 × 56 = 1.288.

"Now the combined strength of the two would be—

T steel + T copper = T compound.
418 + 96 = 514 pounds.

"And the combined conductivity would be—

C. steel + C. copper = C. compound.
.146 + 1.145 = 1.291.

"Or, as we now make it—

.146 + 1.288 = 1.434.

"Thus we have a compound wire weighing 112 lbs. per mile, having a conductivity of from 1.291 to 1.434, according to the copper used, fully equal, if not superior, to that of average No. 8 galvanized iron wire (1.298 to 1.331), which compound wire will require $\frac{5}{1.1\frac{4}{9}}$=4.58, or 4½ miles to be suspended vertically to break of its own weight, being more than 50 per cent. stronger than iron wire in proportion to the weight which it has to sustain. Hence it can probably be put up with fewer poles per mile, thus increasing the degree of insulation.

"I will here insert two tables:

Galvanized iron wire.

Posts.	Sag.	Ti	C	T	$\frac{w}{i}$	$\frac{Ti}{T}$
38	1	144.3	1.136	928	320	.155
38	2	72.2	1.136	920	32c	.077
38	3	48.1	1.136	928	320	.052

Compound wire.

23	1	140	1.331	514	112	.272
23	2	70	1.331	514	112	.136
23	3	47	1.331	514	112	.091

"So that with 23 posts per mile, instead of 38, the insulation would be 33—23÷23=$\frac{65}{100}$=65 per cent. better, and with a sag of 2 ft., the strain on the wire at the insulator would be only about ¼ of that required to break a short length of the wire; and with a sag of only 1 ft., the strain would be less than ⅛ of its ultimate strength. The uniformity and homogeneity of the steel render it less likely to break from flaws (and the short experience which we have had with it shows this). The saving of cost per transportation is evident at a glance.

"Now let us look at a larger wire. Suppose 187 lbs. per mile of steel, and 188 lbs. per mile of copper equal 375 lbs. per mile (same weight as a No. 8 galvanized iron, which has a tensile strength of 1087), and a conductivity of 1.331 (at best average):

	$\frac{w}{i}$	T	C	$\frac{Ti}{w}$
Steel	187	1397	.420	7.47
Copper	188	329	4.324	1.72
Summary	375	1720	4.814	4.59

"Here we have an increase over No. 8 of 1720 – 1087÷1087=$\frac{58}{100}$, or 58 per cent. in tensile strength, an increase of 4.814 – 1.331÷1.331=261 per cent.; or, in other words, we could reach three and a half times as far with the compound wire as with the iron of equal weight per mile, while the insulation could be improved by the use of fewer poles per mile, this wire being nearly sixty per cent. the stronger."

Table showing the relative weight, strength, and conductivity of the compound and other wires.

	$\frac{w}{l}$	T	C	$\frac{C}{C\,fe.}$
Table No. 1.....	375	1091	1.331	1
Table No. 2:				
Steel.....	187	1397	.490	..
Copper.....	188	325	4.321	..
Compound..	375	1722	4.814	3.61
Table No. 3:				
Steel.....	119	889	.311	..
Copper	119	205	2.737	..
Compound..	238	1094	3.048	2.29
Table No. 4:				
Steel.....	52	388	.136	..
Copper	52	89	1.196	..
Compound..	104	477	1.332	1
Table No. 5:				
Steel.....	78	583	.204	..
Copper	297	511	6.831	..
Compound..	375	1094	7.035	528
Table No. 6:				
Steel.....	357	2768	.935	..
Copper	18	31	.414	..
Compound..	375	2799	1.349	1
Table No. 7:				
Steel.....	136	1016	.356	..
Copper	43	74	.989	..
Compound..	179	1090	1.345	1
Table No. 8:				
Steel	56	418	.147	..
Copper	56	96	1.288	..
Compound..	112	514	1.435	1.07

Explanation of Columns.—1st, $\left(\frac{w}{l}\right)$ weight per mile; 2d, (T) tensile strength; 3d, (C) conductivity; 4th, $\left(\frac{C}{C\,fe.}\right)$ conductivity compared with common No. 8 galvanized wire.

Table No. 1 contains the elements for the average of No. 8 galvanized iron telegraph wire; table No. 2, compound wire of equal weight; table No. 3, compound wire of equal tensile strength; table No. 4, compound wire of equal conductivity; table No. 5, compound wire of equal weight and tensile strength; table No. 6, compound wire of equal weight and conductivity; table No. 7, compound wire of equal tensile strength and conductivity; table No. 8, compound wire, or ordinary equivalent of No. 8 galvanized iron wire, such as costs ten to eleven cents per mile at present.

The improvement of Mr. Farmer in the construction of telegraph wire is considered of so much importance as to warrant the insertion here of a more detailed specification of its advantages; and in view of the obstacles encountered in the construction of lines in the Ottoman Empire, to which the energetic director of Turkish telegraph alludes in his letter to the United States Minister resident in Constantinople, inserted in Chapter VI. (obstacles occasioned by the accumulation of ice upon the wires in certain localities), we specially commend the fact that the compound wire seems specially adapted to obviate these difficulties:

"There is a growing tendency in this and other countries to employ larger wire for telegraph purposes, in order to obtain a greater conducting capacity.

"Notwithstanding the many disadvantages attending the use of large telegraph wire, No. 4 has been adopted on important lines and for long circuits, in England, Russia, and other countries, solely for its superior conductivity; and it is well understood by telegraphers in general, that for the rapid and successful operations of the circuits, much depends upon this element. Especially is this the case in wet weather and upon long lines.

"Under certain conditions of the lines, consequent upon wet weather, *superior conductivity* will accomplish that which increased battery power utterly fails to do, and repeaters at intermediate offices, with their necessary main batteries, accomplish but imperfectly and unsatisfactorily, as a general rule, and in many cases fail to do altogether.

"Pure copper wire, having a conducting capacity of nearly 7 times that of galvanized iron wire, has, of course, a great advantage in this respect for telegraph purposes. Its use, however, has been prevented in consequence of lack of sufficient strength to sustain itself.

"In the American compound telegraph wire this vital objection to the employment of copper alone for this purpose is obviated, and a conductivity and relative strength, superior to that of galvanized iron, are combined in a lighter wire.

"The composite parts of this wire are steel and copper, the steel forming the

core, and serving mainly for strength, while the copper serves more especially as a superior conductor.

"In regard to relative strength, it is well known that the breaks in ordinary galvanized telegraph wire, occasioned by accumulations of ice and snow, and from other causes, occur at weak points, or at imperfections which are caused by flaws existing in the iron before galvanizing, as well as from the effects of that process.

"We therefore claim that our compound wire, even with a relative strength no greater, theoretically, than that of a galvanized iron wire, will be much less liable to breakage from these causes, in consequence of the uniformity of strength in the steel core, while, in fact, the relative strength itself, of the compound wire, is very much the better of the two.

"Steel wires, of sizes varying from No. 12 to No. 16, stretched from pole to pole, across streams from one-quarter to three-quarters of a mile in width, in the United States, which have withstood the accumulations of ice and sleet for years, are good illustrations in this connection. One special instance may be cited of a No. 16 steel wire, between fourteen hundred and fifteen hundred feet in length, which has been in operation across the Kennebec River, in Maine, for the past eight years; and which, we are informed by the superintendent of the line, has parted twice only during that period—in each case having been untwisted at a joint by the great strain upon it caused by an immense accumulation of ice, the wire itself remaining intact.

"The advantages of increased conductivity and strength having been briefly set forth, there are other practical advantages to be gained in the use of the American compound telegraph wire, to which we would respectfully call the attention of contractors and telegraph companies.

"Large wire is used only because of its superior conductivity; and it is obvious that a light wire is preferable in handling and stringing, which can be done with less labor.

"Also, maintaining a superior conductivity and relative strength, the lightness of this wire will admit of an average of at least ten poles to the mile less than would be otherwise necessary.

"This reduction in the number of poles per mile will not only conduce to economy in construction, but it will effect a decrease of twenty-five per cent. or more in escape of the electric current.

"In stringing over the tops of buildings, stretches may be safely made double the length of those taken with the ordinary telegraph wire, and yet with less strain upon the insulators.

"Another point in its favor is the imperishable nature of copper, which, in this wire, is the exposed metal; the zinc coating of the galvanized iron being deteriorated near the sea, and from the effect of gases, etc., from chimneys, while copper will remain, under such conditions, unimpaired. In fact, under all circumstances, the durability of the compound wire is greatly superior to that of the galvanized wire in general use."

At the risk of some repetition the following observations upon conductors and insulation are extracted from a more recent publication by the American Compound Telegraph Wire Company, of which Mr. Moses G. Farmer is the consulting electrician.

"The method most commonly in use now, and always likely to be, for the construction of lines of telegraph, is to stretch a line of wire in the air from one pole to another, attaching it to the pole by the intervention of an insulator, connecting each end of the circuit with the ground. The reason we use an insulator is that we wish to transmit as much as possible of the current to the far end of the line before it enters the ground.

"Now, as a current of electricity divides itself into as many branches as there are paths open for it to travel in, and since the proportion of the whole current flowing in any particular path depends on the conductivity of that particular path, in comparison with the sum of the conductivities of all the paths, we wish to diminish the number and value of the paths of escape down the several posts which support the line.

"To maintain a current of electricity in a line of telegraph, we employ some form of galvanic battery. Those most generally used are the Grove nitric acid and the Daniels sulphate of copper battery. About five of the latter are equivalent to three of the former in ability to work a long line.

"Since, however good the insulator may be, some small portion of the current

escapes from the line, over it, down the post to the ground, it is manifest that if the line be long, the posts many, and the insulators very poor, a small portion only of the entering current may reach the far end of the line.

"The law which governs this may be thus enunciated. If the current upon the line near the battery be called the entering current, and that upon the distant end near where it enters the ground be called the arriving current, then the distance to which any stated fraction of the entering current will reach is proportioned directly to the square root of the conductivity of the wires, to the square root of the insulating power of the insulator, and inversely to the square root of the number of poles per mile used. It is customary, of late, to compare the resistance of different wires with one another, by referring them to the standard adopted by the British Association for the Advancement of Science.

"This unit is sometimes called an ohm, or an ohmad, a name given in honor of Dr. G. S. Ohm, who so fully developed the laws which govern the distribution and action of a galvanic current; an unit a million times larger than this, and called a megohm, is used to compare the resistance of insulators.

"A round wire of pure copper $\frac{1}{10}$ of an in. in diameter and about 250 ft. in length, nearly represents this unit of resistance; a nearer representation of it is a round wire 1 ft. in length, and $\frac{143}{10000}$ in. in diameter, made from an alloy composed of two parts of silver and one part of platinum.

Since a pure copper wire is from 6 to 8 times as good a conductor as an average iron wire of the same size, and since the distance to which we can work a line of telegraph depends, among other things, upon the conductivity of the line, it is plain that it would be desirable to use copper if it answered as well in other respects as it does for conductivity; and the first lines in this country were actually constructed of copper, but it was soon found that its ductility and inferior tenacity rendered it inapplicable to the purpose. So iron wires soon came to be substituted for copper, and size No. 9, weighing about 320 lbs. per mile, was selected, as it seemed to generally possess about the same conductivity as did the No. 16 copper wire, which had been hitherto used.

"Since 1847 iron wire has been almost wholly used in this country, until within the past year, when the American compound telegraph wire made its appearance. This wire is the result of almost numberless attempts which have been made to utilize the well-known conducting power of copper; and it is at last accomplished by uniting copper, the best conductor, with steel, the strongest known material; thus at once securing lightness and strength with great conductivity in the same wire, copper being 6 or 8 times as good a conductor as iron, and steel being twice or thrice as strong.

"The American compound telegraph wire has a core of carefully-selected and well-manipulated steel, which core is first tinned, and then has drawn upon it a strip or ribbon of the very best Lake Superior copper, which is selected with the greatest care.

"In the course of its manufacture it goes through a great number and variety of processes, such as annealing, tempering, drawing, etc., and the completed wire is finished by passing it through a bath of melted tin, by which the copper and steel are welded into and made one complete whole.

"The smaller sizes are generally drawn into lengths of 1,000 to 1,500 ft., and are put up in mile bundles, 3 or more pieces being carefully joined together at the factory.

"A wire of ordinary iron, weighing about 320 lbs. per mile, and known to the trade as No. 9, will offer from 17 to 22 units of resistance or ohms to the mile. A compound wire composed half of steel and half of copper, offering the same mileage resistance, will weigh only about 100 lbs. per mile; an iron wire of average quality, weighing 375 lbs. per mile, and known as No. 8, will offer the same mileage resistance as a compound wire of less than $\frac{1}{3}$ that weight.

"None is suffered to go out from the factory as first-class wire, in which the conductivity of the copper is less than 90 per cent. that of chemically pure copper.

"It is manifestly a great advantage to use a light wire, if it presents the required ability to sustain itself, since it produces less strain upon the insulators, which are always brittle, and requires

posts of less strength to sustain it. The cost of transportation is also less, as also is the cost of handling in stringing, etc.

"The compound wire possesses another advantage, based on the fact that steel, even at a low temper, possesses a great degree of elasticity, so much so that it can be stretched or elongated one two hundred and fiftieth part of its length without taking a permanent set; but will, upon removal of the strain, return to its original length; and it is a fact that when a tree falls upon a line of the compound wire and does not break it, when the tree is removed the wire returns nearly or quite to its original position, instead of remaining stretched as does an iron wire.

"From this cause a line of compound wire keeps up to its original height, and does not sag more and more year after year, as an iron wire does.

"In order to show clearly the advantages which the compound wire offers in the construction of lines of telegraph, it may be well to compare the relative conditions as to strength and ability to work lines built of iron wire, with equally efficient lines constructed with compound wire.

"A very common mode of construction has been to use No. 9 iron wire, weighing 320 lbs., and putting it up on 35 poles per mile, with glass insulators on wooden pins, which insulators, in a long-continued rain storm, would not offer more than two or three megohms of resistance. We will suppose one wire used, the posts to be 25 ft. above ground. If the wire be of very good quality it will offer 18 ohms per mile of resistance, and if it be soft it will generally break at a strain of about 1,000 lbs.; but there being always more or less of flaws in a mile of the wire, if it be put up very taut it will break a few times the first year. We will suppose the posts 150 ft apart, and the sag of the wire midway between the posts to be 9 in.; this would be called pulled up pretty straight. The strain on the wire near the insulator would be 250 lbs., or 25 per cent. of the ultimate strength of the iron; and it would be more than that, as the strength of a wire is that of its weakest cross-section, and there being occasional flaws, 250 lbs. would sometimes be as much as ¼ of the real strength of the wire.

"With a mileage resistance of 18 ohms, and with 35 insulators per mile, which offers 3 megohms resistance each in a very rainy day, the fraction of the entering current which would reach the end of the line, 250 miles distant, would be about 5⅓ per cent. The apparent resistance of the line, measured from one end, would be only about 238 ohms, instead of 4,500, which it would be if the line were insulated to absolute perfection. Suppose now that ordinarily 30 Grove cups are used at one end only, the total electro-motive force of the 30 cups will be about 48 volts, and the internal resistance of the 30 cups should not exceed 12 ohms; then the total resistance of the circuit, with all the relays cut out, would be 238+12=250 ohms, and the strength of the entering current would be 192,000 of a megafarad, or 192,000 farads.

"This is from 10 to 15 times as much strength of current as is ordinarily required to work a relay; and, indeed, the 5⅓ per cent. of it, or 10,176 farads, is amply sufficient to work the relay at the distant end of the line.

"We will now suppose that we employ a compound wire weighing 200 lbs. per mile, 90 lbs. of this wire being steel, and 110 lbs. of it being copper—its breaking strain will be about 1,040 lbs.; ¼ of this will be 260 lbs., and if it be put up on 19 posts per mile, with a sag of 16 in. midway between the poles, the ratio of the span to the sag will be the same as in the former case. The tension on the wire will be the same fraction of its ultimate strength, as in the case of the iron wire on 35 poles per mile; and from its superior homogeneity it will be less likely to break.

"Now, on a line thus constructed, the conducting resistance being 7.72 ohms per mile, and there being only 19 insulators of 3 megohms each per mile, we shall find that 34 per cent. of the entering current arrives at the terminal station, 250 miles distant, instead of 5⅓, as with the No. 9 iron wire; and we shall find that 12 cups of Grove's battery will cause as strong a current to arrive at the distant end as did the 30 cups on the previous iron wire.

"Some of the best constructed lines in the United States use a wire of extra quality, weighing 380 pounds per mile, with as low a mileage resistance as 13 ohms.

"These lines are built on 38 to 40 posts per mile, with glass insulators that in a hard rain do not show more than 9 megohms resistance each.

"A line so constructed would be capable of transmitting 90 per cent. of the entering current to a terminal station 70 miles distant, and 10 per cent. of the current to a terminal station 484 miles distant.

"But if a compound wire, half of steel and half of copper, weighing 140 lbs. per mile, and having a mileage resistance of 12 ohms, be put on 12 posts instead of 38, with the same kind of insulators, we should find that 90 per cent. of the entering current could be transmitted over a line 131 miles long, and 10 per cent. over a line 750 miles in length.

"If, instead of the compound wire, weighing 140 lbs.—only about $\frac{3}{4}$ the weight per mile of the iron—we make it weigh the same, namely 308 lbs. per mile, its mileage resistance would be only $4\frac{5}{6}$ ohms; and if it be put up, as in the last example, we should find that 90 per cent. of the current would be received at a terminal station 213 miles distant, and similarly 10 per cent. at a station 1,225 miles away.

"It is clear that the principle involved in the foregoing examples, namely, transmitting an increased percentage of the current by means of superior conductivity, or insulation, or both, is applicable to the double transmission and other intricate systems, as well as to the working of long circuits, and general operations in humid weather.

"*Increased conductivity* becomes of special importance to those systems which strive for greatly increased rapidity of transmission, particularly on long lines, as *this feature alone* aids us to overcome the retardation due to lateral induction.

"Its special advantages are also manifest on lines which may be liable to contact with trees, as the percentage of a current which will pass beyond a given local fault will be greater as the conductivity of the wire is increased. In other words, the greater the conductivity of the wire the less the escape from it.

"We have thus endeavored briefly to set forth a few of the advantages which this wire offers to enterprising contractors and companies which desire to remove the odium that has hitherto been the standing reproach of American lines."

THE TEMPERATURE OF COAL MINES.

From "The Mining Journal."

A paper by Mr. Edward Hull, the well-known geologist, entitled "Observations on the Temperature of the Strata taken during the Sinking of Rose Bridge Colliery, Wigan," was read at the Royal Society last week. Mr. Hull stated that, in an elaborate paper by Mr. W. Hopkins, entitled "Experimental Researches on the Conductive Powers of various Substances," published in the Philosophical Transactions for 1857, an account is given of a series of experiments made under the general supervision of Mr. Hopkins, F. R. S., himself, and Mr. W. Fairbairn, F. R. S., during the sinking of the Astley Pit of Dukinfield Colliery, in Cheshire. At the time this paper was written the depth attained was only a little more than 1,400 ft., and the rate of increase between the depths of 700 ft. and 1,330 ft. was found to be 1 deg. Fahr. for about 65 ft. These observations were subsequently continued until the pits had attained their full depth of 717 yards from the surface. The last observation made was in the shale overlying the coal seam, known as the Black Mine, which it was the object of the proprietor, Mr. Astley, to reach, and the temperature was found to be 75 deg. Fahr. Assuming the "stratum of constant temperature," or, as it is also called by Humboldt, "the invariable stratum," to be that which was reached at 16.5 ft. with a temperature of 51 deg. Fahr., the total increase of temperature would amount to 24 deg. Fahr., giving as the rate of increase 1 deg. Fahr. for every 88,925 ft. This is much below the average rate of increase. During a part of the period above referred to (from 1854-6), another coal pit was being sunk at Wigan, which reached the depth of 600 yards, down to the celebrated Cannel Mine. At this pit similar observations on the temperature of the strata were made very carefully by the manager, Mr. Bryham, which were kindly communicated to myself for publication, and will be found in my work on the "Coal Field of Great

Britain." The ultimate temperature attained in this pit at the depth from the surface of 600 yards was found to be 72 deg. Fahr.; and assuming the invariable stratum to be the same as that at Dukinfield Colliery, the resulting rate of increase would be 1 deg. Fahr. for every 61.5 ft., which accords very closely with the result obtained by Prof. Phillips, F. R. S., at the Monkwearmouth Colliery.

Since the time above referred to, the proprietor of the Rose Bridge Colliery, Mr. J. Grant Morris, determined to carry down the shafts from the Cannel seam to the Arley seam of coal, which was known to lie more than 200 yards below it; and consequently in the spring of 1868 preparations were commenced for carrying out this project. In the incredibly short time of one year and two months the Arley coal was struck, and was found to be of good thickness and quality. The total depth reached was 808 yards, and the ultimate temperature in the coal itself was found to be 93½ deg. Fahr. The manager of the colliery, Mr. Bryham, sensible of the value of observations on the temperature of the strata at such unusual depths (this being probably the deepest colliery in the world, certainly in Britain), made a series of observations with as much care as the circumstances would admit, and has intrusted them to me for publication. The mode of taking the observations was as follows: On a favorable stratum, such as shale, or even coal, having been reached, a hole was drilled with water in the solid strata to a depth of 1 yard from the bottom of the pit. A thermometer was then inserted for the space of 30 min., the hole having been sealed and made air-tight with clay. At the expiration of the half hour the thermometer was taken up and the reading noted. It might possibly be objected that the time allowed (30 min.) was sufficient for the embedding of the thermometer, and that the readings are liable to error from this cause. I feel sure, however, that if any error has arisen it is inappreciable, and does not in the least invalidate the general result. In fact, I am assured by Mr. Bryham that, from actual testing on several occasions, he found less than this time of 30 min. sufficient for the purpose required.

While the temperatures of the strata were being measured, observations were also carried on *pari passu* on those of the open pit during the descent. These are given in the table annexed. By a comparison of the results in the two columns, it will be observed that as the depth increased, the differences between the corresponding temperatures in the pit and the strata tended to augment; in other words, the temperature of the strata was found to augment more rapidly than that of the open pit. The effects of the high temperature and pressure on the strata at the depth of 2,425 ft. are, as I am informed by Mr. Bryham, making themselves felt, and cause an increase in the expense both of labor and timber for props. This colliery, in fact, will be in a position to put to the test our views and speculations on the effects of high temperature and pressure on mining operations. In order to obtain the average rate of increase of heat as shown by the experiments at Rose Bridge Colliery, we may assume, in the absence of direct observation, the position and temperature of the invariable stratum to be 50 ft. from the surface and 50 deg. Fahr., which is probably nearly the mean temperature of the place. With these data, the increase is 1 deg. Fahr. for every 54.57 ft., which approximates to that obtained by Prof. Phillips, at Monkwearmouth, of 1 deg. Fahr. for about every 60 ft. If, on the other hand, for the purpose of comparison, we adopt the measurements for the invariable stratum as obtained at Dukinfield, we find the rate of increase to be 1 deg. Fahr. for every 47.2 ft. as against 1 deg. Fahr. for every 83.2 ft. in the case of Dukinfield itself.

So great a discordance in the results is remarkable, and is not, in my opinion, attributable to inaccuracy of observation in making the experiments. On the other hand, I may venture to suggest that it is due, at least in some measure, to dissimilarity in the position and inclination of the strata in each case. These I now proceed to point out. Rose Bridge Colliery occupies a position in the centre of a gently sloping trough, where the beds are nearly horizontal; they are terminated both on the west and east by large parallel faults which throw up the strata on either side. The colliery is placed in what is known as "the deep belt." Dukinfield Colliery, on the other hand, is planted upon strata which are highly inclined. The beds of sandstone, shale, and coal rise and crop out to the eastward at angles

varying from 30 deg. to 35 deg. Now, I think we may assume that strata consisting of sandstone, shales, clays, and coal, alternating with each other, are capable of conducting heat more rapidly along the planes of bedding than across them, different kinds of rock having, as Mr. Hopkins' experiments show, different conducting powers. If this be so, we have an evident reason for the dissimilar results in the two cases before us. Assuming a constant supply of heat from the interior of the earth, it could only escape, in the case of Rose Bridge, across the planes of bedding, meeting in its progress upwards the resistance offered by strata of, in each case, varying conducting powers. On the other hand, in the case of Dukinfield, the internal heat could travel along the steeply inclined strata themselves, and ultimately escape along the outcrop of the beds. I merely offer this as a suggestion explanatory of the results before us, and may be allowed to add that the strata at Monkwearmouth Colliery, the thermometrical observations at which correspond so closely with those obtained at Rose Bridge, are also in a position not much removed from the horizontal, which is some evidence in corroboration of the views here offered.

Thermometrical Observations at Rose Bridge Colliery.

Date.	Depth in yards.	Strata.	Temperature in open pit.	Temperature in solid strata.
July, 1854	161	Blue shale	— ° F.	64.5° F.
August, 1854	188	Warrant earth	—	66
May, 1858	550	Blue shale	—	78
July, 1858	600	Warrant earth	—	80
May 18, 1868	630	Raven coal	73	83
July 24, 1868	665	Linn and wool	75	85
April 19, 1869	673	Yard coal mine	76	86
Nov. 18, 1868	700	Strong blue metal	76	87
Feb. 22, 1869	736	Strong blue metal	76	88½
March 12, 1869	748	Shale	77	89
April 17, 1869	762	Linn and wool, or shale	78	90.5
May 3, 1869	774	Strong shale	80	91.5
May 19, 1869	782	Blue metal	79	92
July 8, 1869	801	Strong blue shale	79	93
July 16, 1869	808	Coal (Arley mine)	79	93½

CONSTRUCTION OF THE WOLF ROCK LIGHT-HOUSE.*

From "The Builder."

The Wolf Rock was stated to be composed of a hard, dark, felspathic porphyry. Its highest part was 17 ft. above low water of spring tides, which had a rise of 19 ft. The surface was rugged, rendering a landing upon it difficult. The depth of the water close to the rock was twenty fathoms, excepting on the south-east side, where a shoal extended for a considerable distance. In the year 1860, the late Mr. Walker was instructed to furnish a design for, and an approximate estimate of, the cost of the work. These having been approved, the author, who was then completing the Smalls Lighthouse, was appointed to carry out the work as resident engineer. The form and dimensions of the tower differed but little from those of the Bishop, the Smalls, and the Hanois. Its exact height was 116 ft. 4¾ in., its diameter at the base was 41 ft. 8 in., and near the top, at the springing of the curve of the cavetto under the lantern gallery, the diameter was 17 ft. For a height of 39 ft. 4½ in. from the base the work was solid, with the exception of a space forming a tank for fresh water. At the level of the entrance door the walls were 7 ft. 9½ in. thick, whence they gradually decreased throughout the whole height of the shaft to 2 ft. 3 in. at the thinnest part near the

* From a paper read before the Institution of Civil Engineers, in London, by Mr. Jas. N. Douglass.

top. The shaft of the tower was a concave elliptic frustum, the generating curve of which had a major axis of 236 ft., and a minor axis of 40 ft. It contained 44,506 cubic feet of granite, weighing about 3,296¾ tons, and its centre of gravity was 36 ft. 2¼ in. above the base. In consideration of the exposed position of the work, it was determined to dovetail each face stone vertically and horizontally, in accordance with the system suggested by the author's father, and first adopted at the Hanois Lighthouse. This method consisted in having a raised dovetailed band, 3 in. in height, on the top bed and one end joint of each stone. A corresponding dovetailed recess was cut in the bottom bed and end joint of the adjoining stones, with just sufficient clearance for the raised band to enter it freely in setting. From experiments made upon blocks of granite put together in this manner with Portland cement, it was found that the work was so homogeneous as to be as nearly as possible equal in strength to solid granite. In addition to increased strength, this system of dovetailing afforded great protection to both the horizontal and the vertical joints, against the wash of the sea when the work was first set. As an additional precaution, each stone of the first twenty courses was also secured by two bolts to the course below. The masonry, to the level of high water spring tides, was set in fresh Medina Roman cement, part of which was supplied from the Government Stores at Chatham, and part was manufactured by Messrs. Francis & Co., from whom the Portland cement was obtained for setting the work above high water. All the cement used in the work was mixed with an equal portion of clean, sharp, granitic sand, obtained from the stamps refuse of the Balleswidden Tin Mine, near Penzance. This sand was of excellent quality for such work, every grain in it being hard, angular, and rough. Salt water was used for mixing all the cement required for the landing platform and for the solid portion of the tower; above this, fresh water was used. The step ladders for ascending from floor to floor, and the partitions between the rooms and staircase, were of cast-iron, and precaution had been taken to limit the use of wood for the fittings as much as possible, in case of fire. The doors, windows, and storm shutters were of gun metal. The windows of the watch or service room, immediately under the lantern, were specially arranged for admitting air to the lantern and for regulating the ventilation in all ordinary weather. The supply of air was admitted by a valve at the upper part of the window, so as to pass above the head of the light-keeper on duty, and upwards through an iron grating surrounding the lantern floor.

The lantern was one of the cylindrical helically-framed type, designed by the author, and adopted by the Trinity House.

The total cost of the undertaking, including the lantern, the illuminating apparatus, cost of work-yard at Penzance, vessels, and all incidental expenses, might be taken at £62,726.

Bessemer Steel making in France.—The total production of Bessemer steel rails in France in the first six months of 1869 amounted to 19,755 tons, against 10,562 tons in the corresponding period of 1867; it is probable that the French production of this description of rails will show a still further advance in the second half of 1869, as large orders have been given out during the last 2 or 3 months by the great French railway companies. Among the more recent orders of steel rails we may mention one for 2,000 tons, given by the Orleans Railway Company to the Creusot works at £11 7s. 2d. per ton, and another for 3,000 tons, given by the Western of France Railway Company to the Terrenoire works, at £11 10s. 3d. per ton.

At the Liverpool Assizes on Saturday, a piano dealer and tuner of pianos, said to be earning £300 per annum, claimed damages for such injuries received in an excursion train on the London and North-Western Railway as incapacitated him for the pursuit of his calling. Mr. Justice Brett, in addressing the jury, said that if sufferers from railway accidents got annuities equal to their prospective earnings, it would be impossible for the companies to carry on their business. Both parties, he held, should share the consequences of an ordinary liability to accident, and bearing this fact in mind, as well as the fact that railway companies were compelled to carry passengers, the jury should assess damages accordingly. The award of the jury was £600.

THE PURITY OF CROTON WATER.

From "The Chemical News."

The water supplied to the citizens of New York, at the liberal rate of 65 gallons to each person daily, is collected by the various branches of the Croton river from an area of 338 square miles in Westchester, Putnam, and Dutchess counties. The character of this water-shed is a sufficient guarantee of the purity of the water. The surface of silicious gravel rests on hard Laurentian gneiss, and is open pasture or woodland, with few swamps. No factories line the streams, which are liable to contaminate the water with refuse chemicals, and no towns or large villages exist anywhere in the district to pollute the waters with sewage. A recent survey of the water-shed has indicated fifteen points at which dams can be erected for the creation of large storage reservoirs, whose joint capacity would be 67,000,000,000 gallons, or a supply, at the present rate of consumption, for 1,000 days. One of these dams, 650 feet long, is now in process of construction at Boyd's Corner, in Putnam county, 23 miles from the mouth of the aqueduct. When this dam is completed, it will flood an area of 303 acres, and the reservoir thus produced will contain 3,369,206,857 gallons, or a supply for 50 to 55 days of drouth.

An analysis of the Croton water recently made in the editor's laboratory gave the following results for one U. S. gallon of 231 cubic inches :

	GRAINS.
Soda	0.326
Potassa	0.097
Lime	0.988
Magnesia	0.524
Chlorine	0.243
Sulphuric acid	0.322
Silica	0.621
Alumina and oxide of iron	a trace
Carbonic acid (calculated)	2.604
Water in bicarbonates (calculated)	0.532
Organic and volatile matter	0.670
Total	6.927
Less oxygen equivalent to chlorine	0.054
	6.873 grs.

These acids and bases are probably combined in the water as follows :

	GRAINS.
Chloride of sodium	0.402
Sulphate of potassa	0.179
Sulphate of soda	0.260
Sulphate of lime	0.158
Bicarbonate of lime	2.670
Bicarbonate of magnesia	1.913
Silica	0.621
Alumina and oxide of iron	a trace
Organic matter	0.670
Total	6.873

On evaporating a gallon of this water a residue of only 4.78 grains is obtained, the bicarbonates of lime and magnesia being left as simple carbonates.

The following tabular statement shows how favorably the Croton compares with the waters supplied to other cities :

PURITY OF CITY WATERS.

Impurities contained in one wine gallon of 231 cubic inches expressed in grains.

City.	Source.	Inorganic Matter.	Organic and Volatile Matter.	Total Solids.
New York..	Croton, 1869.....	4.11	0.67	4.78
" " ..	Well, 8th Av.....	38.95	4.59	43.54
Brooklyn ...	Ridgewood, 1869....	3.37	0.59	3.92
Jersey City.	Passaic River	4.58	2.86	7.44
Trenton.....	Delaware River	2.93	0.55	3.48
Philadelphia	Schuylkill River.....	2.30	1.20	3.50
Boston.....	Cochituate Lake....	2.40	0.71	3.11
Albany.....	Hydrant.....	8.47	2.31	10.78
Troy.....	Hydrant.....	6.09	1.34	7.43
Schenectady	Well, State St.....	46.88	2.33	49.21
Utica.....	Hydrant.....	5.50	0.96	6.46
Syracuse....	New Reservoir.....	12.13	1.80	13.93
Rochester-..	Genesee River.....	12.02	1.23	13.25
Cleveland...	Lake Erie.....	4.74	1.53	6.27
Chicago.....	Lake Michigan.....	5.62	1.06	6.68
Dublin.....	Lough Vartry.....	1.77	1.34	3.11
London.....	Thames River.....	15.55	0.83	16.38
"	Well, Leadenhall St.	90.38	9.59	9.97
Paris	River Seine....	7.83	1.00	8.83
Amsterdam.	River Vecht	14.45	2.13	16.58
"	Well.....	64.55	4.38	68.93

THE new field gun for India is to be a muzzle-loading 9-pounder bronze rifled gun, weighing 8 cwt., and Col. Maxwell, Royal Artillery, who read a paper on the subject on the 14th ult., stated that the 9th Brigade is about to be armed with the new weapon. The gun will be fitted with Sir J. Whitworth's elevating screw, and, with the carriage and the usual spare gear, etc., will weigh about 32 cwt.

PRACTICE WITH THE TRANSIT.

By W. G. MARCY.

The common series for sine and tangent are :

$$\text{sine } x = x - \frac{x^3}{6} + \frac{x^5}{120} - \text{etc.}$$

$$\text{tan. } x = x + \frac{x^3}{3} + \frac{2x^5}{15} + \text{etc.}$$

or, for small arcs :

$$\text{sine } x = x - \frac{x^3}{6} \text{ nearly ;}$$

and $$\text{tan. } x = x + \frac{x^3}{3} \quad \text{"}$$

Hence the differences, respectively, between the sine and arc, and between the tangent and arc, are $\frac{1}{6}$th of the cube of the arc and $\frac{1}{3}$d of the cube of the arc, nearly.

The higher terms of the series show that this applies more accurately to the sine than the tangent. The differences for 10 deg. are, respectively, .00088 and .00180. The differences for 20 deg., divided by 8, give .00088 and .00186.

In *one degree* curves, in which radius = 5730 feet, the formula

$$.0101 \times \left(\frac{\text{no. deg.}}{2}\right)^3$$

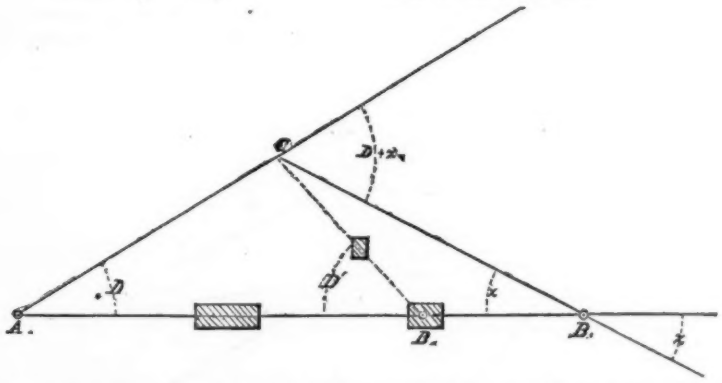
will express the difference between the arc and chord of 40 deg. within 0.1 ; and

$$.01047 \times \left(\frac{\text{no. deg.}}{2}\right)^3$$

will give the difference between the arc and tangent for 36 deg. within the same limits of error.

This is more accurate than ordinary chaining. These differences for equal angles in other curves being inversely as the "degree of curve," we may, in a majority of cases, determine the commencing and terminating points of a curve (marked *P C* and *P I* in the diagrams), independent of the field-book, and often more expeditiously than by use of the regular tables.

The difference between arc and sine 10 deg. being .00088, it follows that when sine 10 deg. is one of two factors, and the other not over 100, the product will be true to 0.1 if we use the arc ; and for angles less than 5 deg. the product will be true to the same limit when the other factor is not over 800.



This consideration will so simplify as to make practicable several devices for expediting operations where trees, creeks, or other similar obstacles obstruct the progress of the survey.

As an example of this application of the formula, suppose an offset to be made from a tangent without making the isosceles triangle. (See Fig.)

Having made the usual offset to *C*, it is impossible to make *B*, it being inaccessible or surrounded by obstacles. Select *C B'*, so that

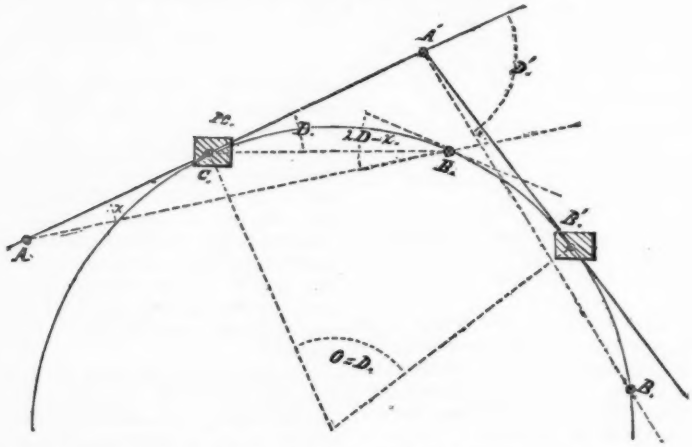
$$x = \frac{A\,C \times D}{C\,B'}$$

can be readily expressed. The deflection $D + \chi$ determines *B'*, which can generally be made in time for the flag-pole at that station.

In passing small obstacles, *D* and χ can

be made so small as to neglect the difference between $A\,C\,B'$ and $A\,B'$; or D may be a multiple of 1 deg., the difference for every 100 feet being as the square of $\frac{1}{4}$, $\frac{1}{2}$, 7, etc., divided by 200—these numbers corresponding to the offsets of 1 deg., 2 deg., 4 deg., etc., for every 100 feet.

To lay out a curve when the first tangent-point, $P\,C$, is inaccessible or surrounded by obstacles:

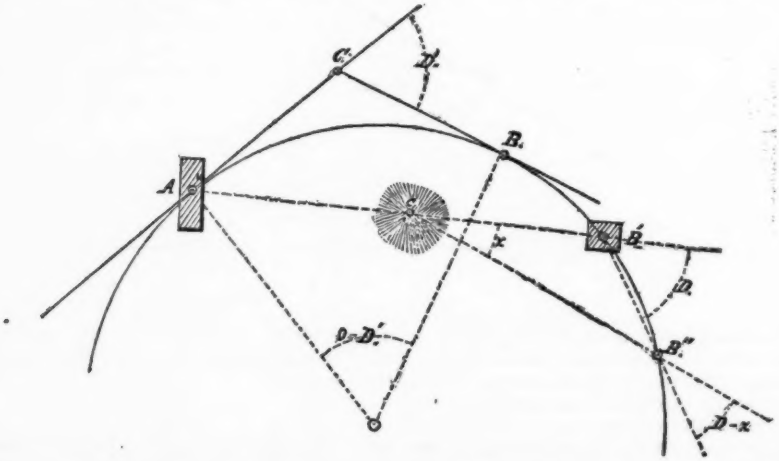


Setting the transit upon the tangent at A, select $C\,B$, so that

$$x = \frac{C\,B \times D}{A\,B}$$

can be easily expressed, the triangle being isosceles if convenient. If necessary more than one point may be determined from A, and, conversely, points of the tangent may be determined from B.

If the obstructions are too large, produce the tangent to A', making $A'\,C =$



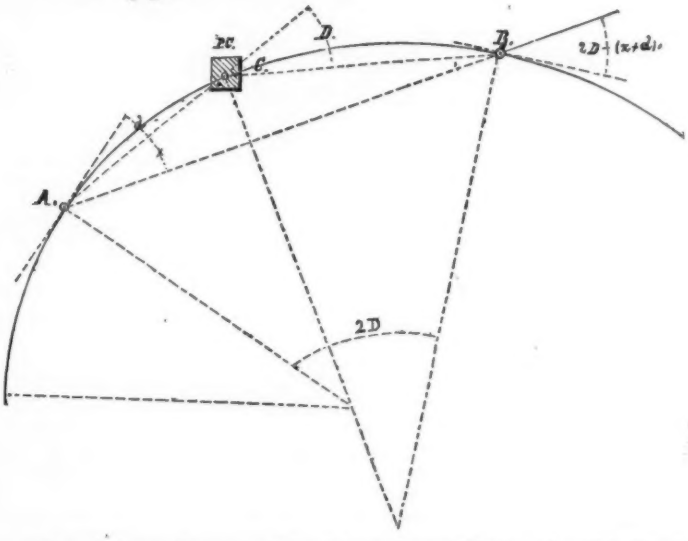
$A'\,B'$; D' corresponding to the centre angle $C\,O\,B'$. Should B' be inaccessible, proceed as originally from A.

Small objects may be passed on a curve, either by removing two equal tangents, $A\,C$, $C\,B$, or a chord, $A\,B'$.

If obstacles occur at B', not seen at A, select $B'B''$, so that

$$x = \frac{B'B'' \times D}{C'B''}$$

can readily be expressed in degrees and minutes, D is the deflection from A to B''.



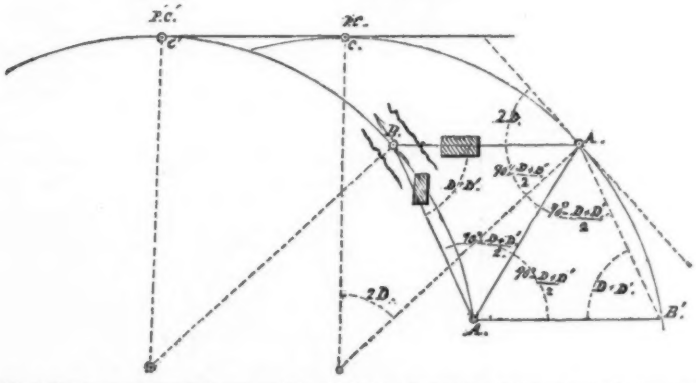
To lay out a compound curve without setting transit at $P\,C$:

The instrument being at A, make the deflection to C; then select $C\,B$, so that

$$x = \frac{C\,B \times D}{A\,B}$$

can be readily found. D is the deflection from A to B.

If C is inaccessible to the chain, measurements may be taken on the curve. This method applies also to reversed curves.



To offset from a curve whose origin is C to a curve of same radius whose origin is C':

From (A) any point of the given curve run $A\,B$ parallel and equal to $C\,C'$. If B is accessible to the chain only, construct the isosceles triangle $A\,B\,A'$. The angle D' in the diagram is the deflection from C' to A'.

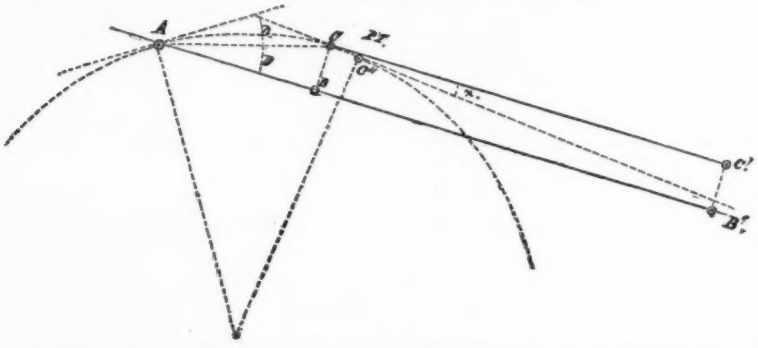
If B is not accessible, describe the isosceles triangle $A\,B'\,A'$.

It will be observed that the point A on

the first curve corresponds to B on the second.

Nothing is limited in this problem but the length of the chord $A'B$.

To change $P\,I$ to $P'\,I'$, not setting up at $P'\,I'$, when it is inaccessible to the instrument or chain, or there are obstructions to producing the tangent:



The instrument remaining at $P\,I$, we form an isosceles triangle; the distance $P\,I$ to $P'\,I'$ being one side, the other determines B on the tangent to $P'\,I'$. Deflection to B is twice the deflection to $P'\,I'$ in returning on the curve; but one-half in advancing. $P\,I$ is the vertex of the isosceles triangle in the former case; $P'\,I'$ in the latter.

If not convenient, the triangle may be scalene.

In these operations the angle and course is rigidly preserved. It is evident that in running trial lines, a wide departure from the limit (10 deg. $\times$ 100) would be both economical in time and satisfactory in results.

To terminate a curve that shall pass its tangent near a distant point B', $B\,B'$ or $C\,B'$ being estimated by the eye:

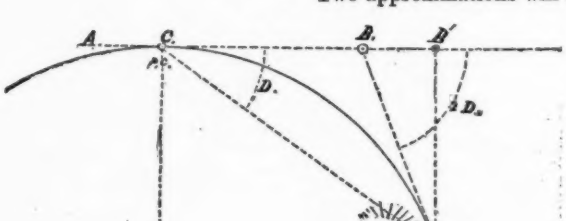
Denote by n the number of stations to make the tangent $C\,C'$ parallel to $A\,B$, n equalling 2 D divided by the degree of curvature.

Let y equal the number of extra stations to C'', $C\,B'$ or $B\,B'$ being expressed in chains of 100 feet.

We have $B\,C = n^2 \times \frac{7}{8} \times$ deg. of curve, nearly, $= \chi \times B\,B' \times \frac{1}{4} = y \times$ deg. of curve $\times B\,B' \times \frac{1}{4}$, nearly. Hence

$$y = \frac{n^2}{2\,B\,B'}$$

Two approximations will often make a closing line. The above value of y will be found to be convenient.



It is required to make the point P with a maximum deflection, 2 D, to avoid P',

passing with a given curve from the tangent $A\ C\ B$. $P\ C$ is the chord of the curve, and $C\ B = B\ P$ the tangents. If it is possible to make $2\ D$ without a continuous curve from P to C, we may run from $P\ B$, commencing at P, and come inside $A\ C\ B$, proving a greater deflection than $2\ D$ possible with a continuous curve.

Hence a continuous curve $C\ P$ makes $2\ D$ a maximum.

Let $P\ C = c$, $P\ B' = d$, $P\ B$ or $B\ C = p$, and radius of the curve $= R$.

We have $p \sin 2\ D = R \tan. D \sin 2\ D = d$; hence

$$2\ R \frac{\sin D}{\cos. D} \sin D \cos. D = d;$$

$$\sin D = \frac{d}{2\ R};$$

therefore $$C = \sqrt{2\ d\ R},$$

and $$R = \frac{C^2}{2\ d},$$

which determines R for any chord.

$C\ B'$ can be found from D and R.

THE HUDSON RIVER SUSPENSION BRIDGE.

From "The Iron Age."

One of the most important engineering enterprises projected in the vicinity of New York is the proposed suspension bridge over the Hudson River, the construction of which was authorized by the recent act of the Legislature incorporating the Hudson and Highland Suspension Bridge Company. This structure will extend across the Hudson River from Fort Clinton, on the west side, to Anthony's Nose, on the east, with one clear span of 1,600 feet, at an elevation of 155 feet above high-water mark. The plans of the company's engineers are not yet fully matured, but enough of the principal features of the work are already known to give a very clear idea of the extent and character of the proposed work. The total length of the bridge, including approaches, will be about 2,500 feet. The entire structure will be composed of steel combination truss and cable work, of great strength and graceful appearance. There will be four systems of twenty cables deeply rooted in the rock and abutments of the towers on either side of the river. Each cable will be about 14 in. in diameter, interlaced and secured by innumerable smaller cables, and will contain altogether 371,-165,750 ft., or 70,302 miles of steel wire. The estimated weight of the iron and steel in the bridge will be about 17,000 tons, and the total suspended weight 9,651 tons. For the towers and approaches, 59,084 sq. yds. of solid masonry will be required. It is believed that the bridge, when completed, will be able to sustain the aggregate weight of sixty locomotives, or more than six times the weight that can ever be crowded upon it at one time. The estimated cost of the work has not yet been announced, but if the plan adopted by the engineers is fully carried out by the company, it will be one of the most remarkable and costly structures of the kind in the country.

As a new link in the chain of railroad communication between the West and the seaboard, the importance of this work is at once apparent. It is said that negotiations are now progressing towards the consolidation of several important roads in this enterprise, among which are the Hudson River, the Boston, Hartford and Erie, the New York, Oswego and Midland, the Delaware and Lackawanna, the Harlem, the Danbury and Norwalk, the New York and New Haven, Hartford, Springfield, Connecticut Valley and others, with their branches and tributaries. Among other benefits, it will reduce the cost of transportation on millions of tons of coal annually, from the Pennsylvania coal fields to all points east of the Hudson River, and on other freights will be saved the expense of transportation over the ferries at this point, which, including the cost of handling and transhipment, is about as great as the cost of moving it by rail from Philadelphia to Jersey City, or from this city to New Haven. The completion of this structure will concentrate the converging lines of railroad at a convenient point on the upper part of th island suitable for the location of a general freight depot, and will enable the principal roads of the Eastern States to make through connections with the West, without depending on the ferries, which are both inconvenient and costly. Steps

should be taken at once to supplement this important movement by the construction of a system of tunnel railroads through the city, for the distribution, at convenient points along our river fronts, of the freight and merchandise brought here for transhipment. This is an important and needed improvement, and its completion would contribute largely to the commercial prosperity of New York. It is announced that work on the bridge will be begun during the coming summer months, and that every effort will be made to insure its completion before the close of another year. This gives the question of tunnel railroads a present importance, and it is to be hoped that, before many months, our enterprising and public-spirited capitalists will have undertaken the work of providing better and cheaper facilities for the distribution of freight and merchandise throughout the city than are now enjoyed by the business community.

PERKINS'S COMPOUND MARINE ENGINE.

From the columns of late English papers we extract the following account of a trial trip of the Filga, a screw tug fitted with compound engines. "The Engineer" says :

"Two generations have all but passed away since Jacob Perkins preached the gospel of high-pressure steam—high-pressure above and beyond any high-pressure with which modern engineers have to do. We think it something to boast of, that the engines of the North London Railway use steam of 160 lbs. pressure ; but Jacob Perkins proposed to use steam of 1,000 lbs., and actually did use it under certain circumstances. The great body of mechanical engineers labor under the impression that Jacob Perkins's ideas died with him. No notion could be more erroneous. His ideas live with his grandson, and we saw them in practical application on Wednesday last, on board the steam-tug Filga, the property of Mr. Henwood. On board this boat, we confess that we stood for the first time over a marine boiler carrying 200 lbs. of steam. Time and space alike forbid us to enter into details. It must suffice to say that the boiler consists of a great number of wrought-iron tubes, about 3 in. diameter outside, and varying in length from 12 ft. to 10 ft., within which the water is contained and round which the heat plays. The engines of the Filga are illustrated, as far as general arrangement is concerned, in the annexed engraving. They consist of four cylinders, arranged steam-hammer fashion. The two upper cylinders are high-pressure 15 in. in diameter. The low-pressure cylinders are immediately beneath them. They are 32 in. diameter, the stroke of both being only 1 ft. The valves are all of the double-beat Cornish type, raised from their seats by spindles driven by eccentrics, but dropped by the pressure of the steam acting on the plus area of one valve. The surface condensers are of a peculiar construction, of which we shall have more to say. The circulating water is driven through it by a pump worked by an eccentric on the screw shaft.

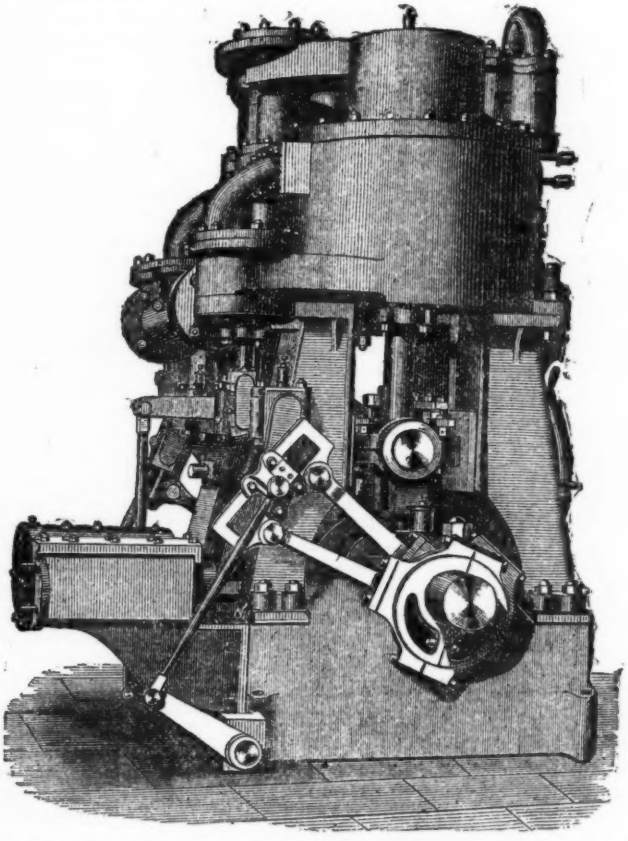
"The Filga is of the ordinary Thames screw-tug type, and it is doubtful if engines of any other form of 80-horse power nominal could have been got into her. She is 70 ft. long, 14 ft. beam, and draws 10 ft. She has a three-bladed common propeller 9 ft. 6 in. diameter, and 12 ft. 6 in. pitch. The boiler has not less than 2,200 square feet of heating surface, the grate surface being but 30 ft. The estimated consumption is a little under 2 lbs. of coal per horse per hour, but the actual consumption appears to be much less. On this point we shall have something more to say.

"The engine illustrated in the annexed engraving is almost precisely the same as that of the Filga, the only difference being that the cold water circulating pump is arranged vertically outside the engine frame instead of horizontally, as shown at the left of the cut.

"The Filga left Blackwall on Wednesday for a run down the river. The trip was in no sense a trial trip. It was simply intended to prove to a select body of engineers that it was possible to work 180 lbs. steam at sea ; and so far it was completely successful. Steam was easily maintained throughout the trip at 150 lbs. to 190 lbs. How such pressures are dealt

with we must explain at another time. No trace of steam was to be seen about engine or boiler, because the joints are absolutely steam-tight.

"The tide was strong against the little vessel on her run down, yet, on the measured mile in the Lower Hope, she attained a speed of 8.33 knots, with nearly 1½ knots of tide against her. This was not a trial run, and no special precautions were taken to secure a good result; but there is no doubt that the result was very good indeed, considering the size of the boat. The general particulars of the run may be thus summed up: The Filga left Blackwall at 12.30, passed North Woolwich Railway pier at 12.55, and Erith at 1.47 P.M. Gravesend was reached at 2.48, Thames Haven at 3.38, and the run back was made at such a pace that Blackwall



was reached at 6.40. Throughout, the working of the engines was most satisfactory. They are of enormous strength, and deserve, from their peculiarities, a separate article to themselves; and the same may be said of the boilers. We shall return, in an early impression, to the consideration of the work now being done by Messrs. Perkins."

The account given by "Engineering" of the same engines and their performance is as follows:

"On Wednesday last a very successful run was made with the screw steam tug Filga, which has just been fitted with one of Messrs. A. M. Perkins and Sons' marine engines, with safety boiler and surface condenser. These engines are on the

compound principle, steam-jacketed, and are of a peculiar yet simple construction, and occupy an exceedingly small space in proportion to the power they develop. The engines of the Filga are fitted with overhead single-acting cylinders, two being 32 in. in diameter, over each of which is another cylinder of 15 in. diameter. In these cylinders work double pistons having a 12-in. stroke, the same rod carrying both pistons. The steam is admitted over the upper and smaller piston, which performs the down-stroke, the steam passing thence to the underside of the lower piston, which makes the up-stroke. Surface condensers of special construction are used, by which means all the steam from the engine is condensed at atmospheric pressure, and the water returned to the boiler at a temperature of 212 deg., which practically means a gain of about ¼ in the fuel. Besides this, there are several other advantages attending this circulation of the water and its re use in a distilled form. It is valuable in preventing deposits in the boiler, so that a fruitful source of explosion is absent, and a further economy of fuel is attained. The use of pure water also effects a saving in the wear and tear of pistons and valves, whilst it is found that the quantity of water required for Messrs. Perkins's condensers is less than that required for an ordinary high-pressure engine. These engines use steam at a pressure of 240 lbs. on the square inch, although we understand that pressures greatly in excess of this are used in the land engines at Messrs. Perkins's works in Seaford street, Regent square. The boilers consist of a number of wrought-iron tubes, ⅝ in. thick, and 3 in. in diameter. These are disposed in horizontal layers, and are connected by small vertical tubes, the flame passing between all the tubes. The boiler of the Filga is composed of thirty sections of eight rows, seven of which are above, and one below, the furnace bars. The tubes are proved at a pressure of 2,500 lbs. per square inch before use, and their construction being that of the separating principle, there is no danger to be apprehended from explosion. The safety-valve is loaded to 400 lbs. per square inch, the bursting pressure being about 20,000 lbs. per square inch. As already observed, these boilers depend greatly for their efficiency upon the purity of the water with which they are fed. The engines are therefore fitted with condensers, and the boilers with an automatic still for that purpose. This still is worked by means of a small pipe coiled in the still ; when once the boiler has been filled, the still is only required to supply the waste.

"These engines, as a rule, are stated to consume under 1½ lb. of coal per horse power ; the returns of the consumption of coal on board the Filga are not to hand as we write, and we therefore defer a complete notice of the results of working until next week. The engines of the Filga are of 80-horse power, but will indicate 240-horse power. On the occasion of her recent trial trip, steam was kept at 180 lbs. pressure at the boiler, and 72 revolutions per minute of the screw shaft were steadily maintained almost from the time of starting to the time of return. Once or twice the revolutions reached 76, and once or twice they fell to 70, but the result of a number of intermittent observations gave 72 revolutions as the general rule. A fair average speed of 8.3 knots per hour was attained running down against tide. The Filga left Blackwall at 12.30, passed the Great Eastern Railway pier at North Woolwich at 12.55, reached the Crossness pumping station at 1 20, Erith pier at 1.45, Tilbury Fort at 2.46, and Thames Haven at 3.38, making a total run of 3 hours and 8 minutes. The vessel's head was then put round, and a rapid run was made up the river to the starting-point. The engines worked most satisfactorily, the general result being that they indicated nearly the same as double-acting engines with 41 in. cylinders and 36 in. stroke."

It was announced from Marseilles on the 13th ult. that the Europe steamer, 3,500 tons, 400-horse power, had arrived there from Bombay on the 12th ult., with 37 passengers. She left Marseilles on the 1st of January, and has, therefore, accomplished the two passages, *via* the Suez Canal, including discharging and reloading, in 70 days.

An improved form of electro-magnetic engine is announced in this city. We prefer not to endorse, just now, the brilliant promises of the inventor and owners.

THE USE OF LEAD PAINT.

From "The Building News."

The methods of manufacturing and preparing white lead for the painter's use are many and various, and would occupy a volume in description, and which would answer no purpose to enter into at length here, seeing that every information on the subject may be gained by consulting Muspratt's "Chemistry Applied to the Arts and Manufactures;" we shall therefore only now notice such facts as are useful to the house painter and decorator to know.

The white lead is, of course, a carbonate or oxide of lead—according to the method of its preparation. It is produced from sheet lead by two standard processes. One, the Dutch method, in which the reactions are effected by operating on metallic lead with acetic acid, and decomposing carbonaceous matters at a comparatively elevated temperature, and without any other moisture but steam; and the other, wherein the carbonate is thrown down from a solution of bassic acetate of lead, by transmitting carbonic acid through it. Large rectangular spaces are formed, enclosed by stout walls of brickwork or masonry, within which pots of acid containing coils of sheet lead are piled in stacks. These stacks are built up of layers of dung, acid pots, lead and boards, alternately. Eight layers of pots usually constitute the stack. Spaces are left at one end in every other layer, in order to create a thorough draught. Every stack contains about twelve tons of metal. A period, varying from five to six weeks, is allowed to convert the sheet lead into carbonate. The English method is a similar process to the above, but, instead of dung, spent tanner's bark is used, which, although slower in its operation, has the advantage of not darkening the lead by sulphate of hydrogen, which the dung evolves. With tan, nine or ten weeks are required to carbonate the lead; by the latter method the particles of lead are more minutely divided and finer; consequently, in use it covers better. It used to be the practice to grind the lead into an impalpable powder, and make it up into cakes for the market; but the process was so destructive to the lives of the workmen concerned that it has been virtually discarded, except for small quantities sold as dry white lead. The practice now is to compound it at once with the linseed oil. This is effected by an apparatus called a kneader, somewhat similar to that used in large bread-baking establishments. This is a cylinder in which a square iron bar, furnished with arms, is fixed longitudinally, and is turned by steam-power. All the materials—white lead and oil—to the extent of eight per cent. of the lead compound, are introduced by the doors, which are firmly closed. When the two are mixed the paste is withdrawn and ground to make it more homogeneous. The purest white leads are alone fitted for the painter's use in interior decoration. There are several of these in the market under the names of London white, Nottingham white, flake white, and the Belgian white—called Kreuzer white, and numerous others not necessary to our purpose to name, these being all white leads, but differently prepared. Pure white lead, when properly prepared, is the most valuable white we have for mixing with oil and making of paints; it is a pure white which will keep its color under all ordinary circumstances, and will mix with most colors without injuring them or being injured by them, and is capable of producing thousands of tints by admixture with other pigments; there is no other white with equal body when ground in oil, or that will cover as well; many substitutes have been tried, but none have as yet stood the test of practical use as compared with white lead. Its purity is not injured, or very little, by light, oxygen, or pure air, but is so, more or less, by sulphuretted hydrogen, damp and impure air. In using it as a white paint, it is most durable, keeps its color best, and is least liable to crack or peel if it is used with pure linseed oil alone, well mixed and passed through a fine straining sieve before it is used; it is well also to add a little black or blue to it in mixing, which will help to purify the white and resist the coloring effect of the oil.

In finishing white it is usual to add about one-third turpentine, as it assists its working in painting, but when it is used as flatting, *i.e.*, dead color without

gloss, we find in practice that the less oil is contained in the lead the more successful the flatting. We therefore beat the lead up in turpentine alone to a proper consistency; it is then left to stand for 10 or 12 hours, when the oil previously contained in the lead will rise to the surface and may be skimmed off; if the color is then too thick for working with, more pure turpentine may be added. We thus obtain the purest whites, and, by mixing, the most delicate tints of color it is possible to get from white lead in oil. We have hitherto been speaking of pure white lead alone, which may be known by the purity of its whiteness, its great density, solidity, and absence of spongy or granular appearance. Age improves its quality. It is supposed that in time a portion of the water it contains evaporates, and it thus solidifies. When white lead has been packed in cask for a long time, when opened the lead will be found to have sunk or diminished in bulk considerably, or solidified. New lead is distinguished by a softness and oily appearance, and consequent want of solidity; but if the lead is really good, the difference between old and new is not of very great importance for the generality of work. Unfortunately, white lead is subject to great adulteration, and this is invariably done in the manufactory. According to Muspratt, all the white lead which is manufactured into paint is more or less adulterated. Again, he says that some of our English white leads are pure, also the Kreuzer white, but the compounds sold under the names of Venetian white, Hamburg white, Dutch white, etc., are all adulterated to a very great extent.

The principal ingredient used for adulteration is sulphate of baryta, but whiting and other earths are used for that purpose, whereby its valuable properties are deteriorated and the public swindled.

Of three samples of white lead sent to M. Louret for analysis, the results were as follows: 1 grm. of No. 1 contained 0.695 of white lead, and 0.305 of sulphate of baryta; 1 grm. of No. 2 contained 0.340 of white lead, and 0.660 of sulphate of baryta; and 1 grm. of No. 3 contained 0.282 of white lead, and 0.718 of sulphate of baryta; yet hundreds of tons of these mixtures are sold annually as white lead at three or four shillings a cwt. less than he pure article. The adulteration may be detected by simply contrasting the pure white lead with such as is suspected to be adulterated. It is said that it may be detected by digesting the sample in dilute nitric acid, which dissolves the lead, but leaves the sulphate of baryta; however, it will be found that sulphate of bartya and whiting, when ground in oil, become discolored, in consequence of their want of body, and greater power of absorbing oil. Glaziers' putty is an example of this. When pure it is made of good whiting and linseed oil alone; the oil turns the whiting into a yellow stone color. It follows, as a matter of course, that if whiting or sulphate of baryta is mixed with white lead, the whiteness of the lead is impaired, its body weakened, and it will not cover as well. We have found in practice that two coats of pure white lead when mixed as paint will cover better or make a more solid ground than three coats of the slightly adulterated, or than four coats of the common or worst lead. Therefore it may be accepted as a fact proved by years of experience, that in its general usefulness, its powers of preserving and giving protection to wood or other materials, in producing good work, and, in an economical point of view, pure white lead, although the dearest in the market, is in all essentials the cheapest in practical use.

Flake white is another preparation of white lead in the form of scales or flakes, hence its name, and is an oxidized carbonate of lead, somewhat purer in color than the ordinary white lead, and is usually ground in poppy oil, and is principally sold by the artists' colormen, but is of great service to the decorative artist when a pure white is required; also in the finishing of imitation marbles in enamel work, *i. e.*, polished paint. It may also be used with advantage in varnish, being exceedingly fine in texture, and free from grit. Zinc white is also a useful white, and may be used either in oil or water. It is a pure oxide of zinc, and has one or two advantages over white lead, inasmuch as it is permanent under all circumstances, and comparatively innoxious both in its manufacture and use; in itself it is a bad dryer, but salts of zinc is mixed with it, which causes it to harden. There are four kinds—snow white, zinc white, stone grey, and grey oxide. The first two are of an unalterable white color; oxide of

zinc is also used in paper staining. Notwithstanding all its good qualities, zinc white is not a favorite pigment with the house painter, principally on account of its want of body. In practice this is found a great preventive to its general use; it takes four coats of zinc white to produce as good a body as three coats of pure white lead will do, thus adding the extra cost of labor and material for one coat over and above the cost of white lead paint. It has, however, many admirable qualities, and may be used for special purposes with advantage; it is rather superior in whiteness to white lead, and is good as a finishing white, or with delicate tints on a ground work of white lead, and may be used in varnishing enamel colors.

If the chemistry of the future can discover a method of manufacturing it with an equal body to white lead, we may safely predict that it will supersede that pigment.

The deleterious effects of white lead upon the health of the workman is a well-known fact. The operative painter is peculiarly subject to its poisonous properties —its effects are seen in the pallid face, care-worn and wrinkled appearance, the attenuated frame, bad breath, and obstruction of the bowels, commonly called painter's colic; in many cases, paralysis follows after colic; we have seen the hands and arms drawn up and distorted and utterly useless. Lead has been found in many cases to have impregnated the whole system. It is scarcely possible for the painter in using white lead paints to escape its effects altogether, however careful and cleanly he may be in his habits, although we have known some who have lived to a good old age without having a day's illness which might be traced to that cause, but we are quite satisfied that much of the ill consequences may be traced to the workman's own want of care and cleanliness. We would strongly insist upon his washing his hands in every case before he touches his food, and clean the paint from under and about his nails. A good practice, which we are glad to see spreading, is to wear linen overalls, cap, jacket and trousers. He should always cast them off before he leaves his work, and not wear them constantly, as some do; he will thus get rid of all trace and smell of paint from his person until work time next morning. On the contrary, the man of careless or dirty habits, who does not adopt these necessary precautions, carries about with him continually the fumes of lead; and when he sits by the fire at home at night, after his day's work is done, the heat will cause a vapor to exude from his garments, carrying with it minute particles of lead, which he and others in his immediate vicinity inhale to his and their detriment. When he is eating, the paint from his hands is transferred to his food, consequently he swallows particles of white lead, thus producing disease and all its attendant train of evils. This is not a fancy picture, but is a stern fact of every-day occurrence, and one which we have seen in numberless instances, and we fully believe that it is this gross carelessness alone that brings to our hospitals three-fourths of the cases of lead poisoning. There can be no doubt but that much of this evil may be avoided by attending to the beforementioned simple precautions. It is a melancholy fact, that rather than take this small amount of trouble, many will suffer the excruciating pains attendant upon lead poisoning, and fly to gin or other spirituous liquors for temporary relief, thus adding to, instead of diminishing the evil; fat bacon and other fatty meats are considered good as a preventive, as they help to clear the lead out of the system; purgative oils occasionally are useful, but we believe in the good old adage that prevention is always better than cure.

In all there are 27 tramway companies asking for powers over 515 miles of road, with a capital of £4,000,000. For London alone there are 7 companies seeking powers over 125 miles in some of the most important streets; while others have in contemplation systems of tramways for Manchester, Liverpool, Birmingham, Leeds, Glasgow, Portsmouth, and Plymouth.

The caisson for the east pier of the East River bridge is soon to be lowered, to place in 18 ft. of water (mean high tide). Its air-holding qualities have been recently tested and found to be quite satisfactory.

The conflicting accounts in English and French journals, leave us in doubt about the merit of Boutet's bridge system.

SUBMARINE WARFARE.

In some recent letters from Capt. J. Ericsson to the editor of "Engineering," the writer offers the following solution to the problem "How to defeat monitors superior in thickness of armor to our own."

A heavy body of regular form, whatever be its specific gravity, projected laterally through the air, commences to fall from the instant of leaving the muzzle of the gun; describing during its progress a parabolic curve considerably foreshortened, owing to atmospheric resistance. But a body of regular form projected under the surface of water or other fluid, in a horizontal or inclined direction, will move in a *straight* line, provided its specific gravity be equal with that of the fluid. In other words, a heavy body of any density whatever moving through the atmosphere, is inexorably under the influence of the gravitating force of the earth; while a submerged body, the weight of which is equal with its displacement, is not affected by gravitation. If put in motion under the surface of a quiescent fluid of unlimited extent, such a body will continue to move in a straight line until the motive energy which propels it becomes less than the resisting force of the surrounding medium.

Starting with these cardinal propositions, I entered, some 25 years ago, on the task of solving the problem of submarine attack, viz., the propelling or projecting below the surface of the water of an elongated shell containing explosive substances to be ignited when reaching some point under the bottom or bilge of an opponent's vessel. The most obvious method of carrying out the idea is that of projecting the elongated shell by means of some contrivance applied near the bottom of the aggressive vessel. Such a method I proposed to the Emperor of France in the month of September, 1854. The device consists of a long narrow chamber arranged near the bottom of the vessel, communicating with the sea and provided with a sliding valve at each end. The outer valve next the sea being closed, the shell is inserted in the chamber, after which the inner valve is closed and the outer valve opened. The means adopted for projecting or pushing out the shell is simply a rod connected with a steam piston. The forward end of the shell being provided with a suitable percussion lock fitted with a protruding trigger, it will be readily understood that when this strikes against an object, the lock, as in ordinary fire-arms, will cause the ignition of the charge within the shell. At close quarters such a method of attack will unquestionably be found very effective—indeed, infallible; but unless the opponent's vessel can be approached very near, it will prove abortive. Evidently, if the shell be projected in any direction not parallel with the line of keel while the aggressive vessel is in motion, a side resistance will be offered by the stationary water of the sea, which will divert the course of the missile the instant it is deprived of the guiding power of the chamber from which it is ejected. Currents will, from the same cause, change the intended course. It need scarcely be observed that, in addition to the difficulty of controlling the direction of the shell, the force imparted to the latter, whether steam or compressed air be employed, is insufficient to propel it to any considerable distance. In order to meet these serious practical objections, viz., that the shell cannot be propelled far enough, and that its course cannot be controlled, I have resorted to a device by which any desirable amount of propulsive force may be imparted irrespective of the distance traversed, and by which the course of the missile is under perfect control during its progress to the intended point. Persons of a mechanical turn of mind, in almost every country, have for a long time been engaged in contriving torpedoes to be propelled under water by independent motive power of various kinds, for the purpose of blowing up vessels. The Austrian torpedo, urged through the water by means of screw propellers actuated by compressed air, may be classed as one of this numerous tribe, the reported terrible nature of which has from time to time frightened naval constructors, and amazed some unmechanical sailors who have witnessed the trials, and found that the mysterious body actually can move under water. Proper investigation of the subject, however, exposes imperfections of the Austrian torpedo which render it,

like all its predecessors, a mere mechanical toy. It should be borne in mind that atmospheric air compressed, so as to exert a pressure of only 300 lbs. to the sq. in., weighs nearly 2 lbs. to the cubic ft. Consequently, the amount of motive force which the torpedo is capable of containing will be found wholly insufficient for its effective propulsion; while the want of means for directing it to the desired point presents an insuperable objection. As before stated, I have contrived a torpedo that may be propelled with any requisite amount of force, irrespective of distance, the course of which is under perfect control, notwithstanding currents, and which may be directed with perfect certainty to an object in motion. In contradistinction to the term *shell*, applied to the structure of 1854, which was propelled alone by *vis viva* imparted, as before described, I propose to apply the term *torpedo* to the contrivance now to be considered.

It should be observed that nearly all attempts to propel bodies under water have been successful as regards maintaining a given depth. The self-evident device of applying a fin or horizontal rudder on each side, operated by a piston or elastic bag actuated by hydrostatic pressure, has been adopted in all. It readily suggests itself to the mind that an increase or diminution of draught, attended as it is with a corresponding variation of pressure, may be made subservient in changing the inclination, thereby establishing a tendency of the horizontal rudder, either to elevate or depress the torpedo during its forward motion. Thus, by a proper adjustment and application of the hydrostatic pressure, the torpedo may be made to move at any desirable depth below the surface of the sea. Nor has any difficulty been experienced as regards the instrument of propulsion in the experiments made since the introduction of the screw propeller. But the difficulty of procuring the requisite amount of motive force for actuating the propeller, and the absence of means for directing the torpedo, have in each instance defeated the object in view.

Before proceeding to consider the important question of *guiding* the torpedo, I will now briefly describe my method of obtaining the required power for actuating the propellers. A reel, of about 6 ft. diameter, revolving on a horizontal axle, is applied near the chamber from which the torpedo is ejected, one end of the axle being supported by a suitable bearing, while the other enters a capacious air vessel through a stuffing box. The end thus inserted in the air vessel is perforated longitudinally for a short distance, and provided with an opening in the side at the point where the perforation terminates. A tubular rope, ½ in. in diameter, composed of hemp and vulcanized rubber, is connected with this opening, and then coiled around the reel a certain number of times, and lastly, connected with the rear end of the torpedo. The air vessel into which the perforated axle of the reel enters, being charged with compressed air (by means of force pumps worked by steam power), it will be readily understood that the compressed air will pass through the axle, then through the several coils of tubular rope wound round the reel, and ultimately reach the rear end of the torpedo, where the rope is attached to the rotary engine which actuates the propellers. Accordingly the propulsion of the torpedo may be regulated by simply opening or closing the aperture of the perforated shaft within the air vessel. The rotation of the reel, consequent on the onward movement of the torpedo, obviously cannot interrupt the passage of the compressed air through the coils of the tubular rope; hence the supply of motive force will continue undiminished during the onward movement. The tubular rope being ½ in. diameter in the bore, it will be found by calculation, that a quantity of compressed air, sufficient to develop at least 10-horse power, may be transmitted through it during the progress of the torpedo, whether far off or near the aggressive vessel. The arrangement thus described being sufficienly simple to be comprehended without entering into detail, it will only be necessary to state that the tubular rope, after leaving the reel under the deck, is made to descend through a vertical tube into the torpedo chamber, in order to prevent an entrance of water at the point where the rope passes out. Also, that *two* propellers are employed, revolving in opposite directions round a common centre—indispensable to prevent the torpedo itself from rotating when subjected to the powerful torsion produced by a *single* propeller actuated by the motive force which may

be transmitted through a tubular rope of ½ in. bore.

I will now proceed to describe my method of guiding the torpedo, premising that the external casing which contains the mechanism and explosive compound, is heavier at the bottom than at the top, in order to preserve a vertical position; and that, in addition to the fins for regulating the draught, the torpedo is provided with a vertical balance-rudder for directing the lateral course. The reel being 20 ft. in circumference, it will be seen that the tubular rope need only be coiled round it 75 times to admit of attack at a distance of 1,500 ft., probably far enough, since the position of the aggressive vessel may be changed at all times with desirable rapidity.

The apparently absurd proposition to direct and change the course of the torpedo at will, on board of the aggressive vessel, without external aid, is solved by the following simple expedient. A small elastic bag connecting the tubular rope with the induction pipe of the rotary engine, is attached to the side of the tiller of the torpedo's balance rudder. As the compressed air during its passage to the motor must pass through the elastic bag, the latter will expand and contract with every change of internal pressure. And as such change will depend on the quantity of compressed air admitted into the tubular rope, the expansion and contraction of the bag is evidently under perfect control. Now the power of this bag to resist internal pressure may be so proportioned that, when maximum pressure is admitted, the swelling of the bag will cause the tiller to move 20 deg. to port; and when the pressure is reduced 25 per cent., the accompanying contraction will move the tiller 20 deg. to starboard. Thus by admitting more or less compressed air into the tubular rope, thereby changing the dimensions of the bag, the tiller will assume any desirable angle within 20 deg. on either side of the torpedo's centre line.

Accordingly, the direction of the torpedo will be as completely under the control of the hand which admits the compressed air to the tubular rope, as if an intelligent directing power resided within the torpedo itself. Probably, no greater mechanical feat than this can be instanced. In smooth water, the telescope will enable the operator to trace the course of the torpedo by the copious formation of air bubbles on the surface of the sea. At other times, a small float attached by a string, will clearly indicate the position; while at night, a small light in the float, seen only from the aggressive vessel, will inform the operator if the missile is on the right road to the intended point. It need scarcely be observed that the explosion of the torpedo will sever the connection with the tubular rope, which thus may be hauled in by turning the reel. Should the intended object not be reached, the admission of compressed air to the tubular rope will be shut off, and the torpedo hauled in, or sent out on a new errand.

The scope of the device, thus described, is, of course limited; yet, had the Italians possessed it, the result at Lissa would unquestionably have been reversed. No harbor can be entered which is protected by it; nor would any amount of vigilance save vessels from destruction on an enemy's coast defended by it; the Hercules and Rupert, with their ponderous armor, would be as easily destroyed as the unarmored Inconstant.

In my recent letter to the editor of "Engineering," it was admitted that the Devastation and consort could steam up the Hudson in spite of batteries and monitors. But small iron-clads of the monitor type without turrets, provided with the reel tubular rope, and torpedoes charged with 500 lbs. of dynamite, could sink Mr. Reed's breastwork monitors before reaching the Hudson.

As stated, the scope of this mechanical device is but limited. Fully impressed with this fact, my labors were early devoted to plans for carrying on submarine attacks by means of which the contest might be removed to the open sea. Before the close of the late war, the problem was satisfactorily solved; and during the month of November, 1866, the leading features of a new system of naval attack were confidentially laid before the King of Sweden and Norway, the Swedish Minister of Marine, Count B. von Platen, and Commodore A. Adlersparre.

Let me add, for the information of your readers, that my object in giving an account of my labors connected with submarine warfare, is simply that of demonstrating the futility of encasing ships of

war with huge masses of iron, and showing the absurdity of wasting millions of tons of coal in propelling weight which does not protect.

A NEW SYSTEM OF SUBMARINE ATTACK.

In the above communication I stated as a general proposition: that a heavy body of regular form, of any density whatever, moving through the atmosphere, is inexorably under the influence of the earth's attraction, and therefore describes a foreshortened parabolic curve during its flight; while a submerged body, the weight of which is equal with the weight of the water it displaces, is not affected by the earth's attraction ; and that consequently, if put in motion under the surface of a quiescent fluid of unlimited extent, such a body will continue to move in a *straight* line until the motive energy which propels it, becomes less than the resisting force of the surrounding medium.

In virtue of the first part of this general proposition, a heavy body may be projected in such a manner that the termination of its trajectory shall make any desirable angle, less than 45 deg., with the horizontal line, independently of the length of the chord of the trajectory. In other words, the body may be projected at *variable* distances over water, and yet strike its surface at any desirable angle. This important result is effected simply by varying the relative proportion between elevation and strength of charge. The second part of the stated general proposition is of equal importance. It points to the fact that the trajectory may be extended in a straight line under water, to any desirable distance, irrespective of the *speed* of the projectile. Accordingly, a shell may be projected from one vessel towards another within moderate ranges, in such a manner that it shall dip into the water at a considerable distance from, or close to, the vessel assailed, independently of the distance between the two vessels. Also that the shell may be projected at such an angle that the prolongation of its trajectory in a straight line, after contact with the water, shall strike the hull of the vessel assailed, at any desirable depth below the surface.

That a certain relation between charge and elevation enables us to project a *spherical* shot, with considerable accuracy, in such a manner as to strike the water at any desirable distance from an opponent's vessel, at angles within 45 deg., will be admitted. Hence, if the trajectory be such that its extension in a straight line from the point of contact with the water leads to the hull of the vessel assailed, the latter will be hit—on condition, however, that the shot is not diverted on entering the water; and provided its *vis viva* be sufficient to overcome the resistance encountered during its passage through the water. These indispensable conditions, which apparently cannot be complied with, point to the difficulty of hitting a vessel below the water line. And if we suppose that the projectile is not spherical, another serious difficulty presents itself. An *elongated* body will not bend to the curvature of the trajectory, but retain during its flight the same inclination as the gun from which it has been projected ; hence it will fall nearly flat on the surface of the water at the end of its course.

Agreeable to our general proposition, a regular body, weighing as much as the water it displaces, is independent of the earth's attraction ; but there is another force which, notwithstanding the absence of any gravitating tendency, will cause a body of regular form moving under water to deviate from a straight line and rise to the surface. A cone moving in the direction of its apex and in the line of its axis horizontally, or on an incline, will, owing to the inertia and the nearly incompressible nature of water, more readily displace the column which rests upon and depresses its upper half, than the column from below with its lifting tendency. Consequently, the course of the conical body will be diverted from the straight line upwards, describing a curve nearly elliptical, and quite sudden, if the speed be great. A cylinder with semispherical ends will, from the same cause, ascend to the surface if moved in the line of its axis ; while a cylinder with flat ends will take a downward course, gradually increasing its inclination until at last the axis assumes a vertical position. Obviously, the lower part of the forward flat end encounters a greater resistance than the upper part ; hence the lower half of the transverse section of the cylinder suffers an excess of retardation, which occasions the downward course described.

The question whether the apparently insuperable difficulties thus pointed out

may be overcome by mechanical expedients, has, as already stated, occupied my attention for a long time; and numerous experiments have been made to test the efficacy of devices resorted to on theoretical considerations. But it is not my purpose to enter on a description of these devices at present, on grounds that will appear hereafter. Accordingly, I will assume that the axis of the elongated projectile during its flight through the air is parallel with the trajectory, and that on entering the water the projectile will not be diverted, but continue to move under the surface, with the same inclination it had on coming in contact with the dense medium.

The accompanying sketch presents the main features of my new system of submarine attack so distinctly, that it will be superfluous to enter on a general explanation of the nature of the scheme. It may be well to state, however, that the elongated shell is charged with dynamite and provided with a percussion lock and trigger, to be actuated as described in my former communication relative to the self-acting torpedo.

It is well known that numerous plans have been suggested during the last few years, for firing under water, for the purpose of piercing the hull of iron-clad vessels below the point protected by the armor. In several instances these plans have been carried into practice with the invariable result that the resistance of the water has been found so great, even at very short distances, that an ordinary wooden hull has proved to be impenetrable. The plan now under consideration bears no resemblance to these projects. In the first place, the attack is made at a distance; and, secondly, the force of the missile on reaching its destination, need only be sufficient to actuate the trigger which causes the ignition of the explosive charge.

Apart from the theoretical considerations relating to the course of the elongated shell under water, the practical question of *motive power* to propel the same presents itself at the first step in the investigation. It is hardly necessary to state that the force relied upon is the *vis viva* possessed by the shell on coming in contact with the water. Before estimating this force it will be proper to call attention to the fact that my new system, to be effective and a practical success, does not call for attack at a great distance, provided the vessel from which the missile is projected has greater speed than the opponent, and at the same time adequate protection against his artillery. No reason whatever can be assigned why the attack should not be successful, and the destruction of the vessel assailed as certain if the distance of 500 ft. were the limit, as if a range of 5,000 ft. better suited the new system. It will be inferred from this explanation, that although there is no special limit within ordinary ranges, the plan is to attack at distances not much exceeding 500 ft., unless the sea be very smooth.

The *vis viva* of a shell 15 in. in diameter, of such a length that it displaces 500 lbs. of water, may be readily estimated if we suppose the charge of powder in the gun to be so regulated that the shell will enter the water at the required rate of 400 ft. per second; thus, $\frac{400^2}{64} = 2500 \times 500 = 1{,}250{,}000$ ft.-lbs. A cylindrical body 15 in. in diameter, with semi-spherical ends moving at a rate of 50 ft. per second under water, requires a constant motive force of somewhat less than 400 lbs. Assuming, then, that the shell passes through 120 ft. of water—the mean distance represented by the accompanying diagram—we have a resistance of $120 \times 400 = 48{,}000$ ft.-lbs. to overcome. The motive force, it will thus be seen, is more than 24 times greater than the resistance; hence no doubt can be raised as to the adequacy of the motive power furnished by the *vis viva* of the shell. It should be observed, that the resistance is very great at first, and that the speed of the shell diminishes in a very rapid ratio; but it would be futile to present a formula expressing the ratio of speed and resistance since the *form* of the body is the chief element in the calculation. Suffice to say, that while the resistance against a blunt body is so great that it can hardly be overcome, one provided with a sharp point enters the water with much facility, even at the rate of 400 ft. per second. The passage of the shell through the water will, therefore, be sufficiently rapid to reach the desired object in proper time.

With reference to the gun, it should be borne in mind, that the very low speed of the shell, and the consequent small charge

of powder needed, render heavy metal unnecessary. Besides, slow burning cake-powder contained in cellular cartridges, will be employed for the purpose of checking rapid ignition, and in order to sustain an uniform pressure during the discharge. By reference to our sketch it will be seen that the guns are loaded from below, and for that purpose so arranged as to admit of being depressed 60 deg. Gun carriages are dispensed with, the trunnions being suspended by adjustable pendulum links secured under the turret roof. The recoil is checked by buffers attached to the turret wall in rear of the breach.

I feel called upon to state, that loading guns below deck, as here shown, was planned by me, and drawings representing this method exhibited in New York several years before it was claimed by certain American engineers as their invention.

Respecting the safety of the charge in the shell from ignition during the discharge, it will be well to observe that efficient means have been devised to prevent such an accident. With reference to the *calibre*, it is evident that this system of attack calls for dimensions that will admit a shell of sufficient capacity to contain a charge which by its explosion will destroy a first-class ship of war built on the cellular plan. Nothing short of 300 lbs. of dynamite will suffice for this purpose; hence nothing less that 15-in. calibre will answer. The American and Swedish 15-in. guns are admirably calculated for the purpose, although they are unnecessarily heavy.

European savans, especially certain Swedish naval artillerists, who have criticised my advocacy of the 15-in. smooth-bore gun, will understand on looking into this matter, why I have persisted in advising the Scandinavians to carry this large calibre in their monitor turrets as the most effective weapon against their powerful neighbors. Assuredly the Danes will have no cause to fear the Prussian König Wilhelm or Friederich der Grosse, when their ports are defended by vessels armed with guns by means of which 300 lbs. of dynamite may be exploded under the hulls of the intruders.

The important question of hitting the intended object will be best answered by a careful examination of the accompanying diagram, which cannot fail to convince naval men that, in moderate weather, the elongated shell may be made to dip at the proper distance from an opponent's vessel. The diagram clearly shows that no great accuracy is called for, and that the shell may dip at various distances from the vessel assailed and yet strike the hull. It should be observed that the vertical scale of the diagram is different from that of the horizontal, in order not to place the vessels too far apart for the limited size of this page; consequently the trajectory shown is distorted.

The turret, it may be briefly noticed, in which the light 15-in. shell guns are mounted, is composed of flat wrought-iron plates forming a square box, wide enough to accommodate the two pieces, suspended as already stated, by pendulum links secured under the turret roof. A massive central shaft of wrought-iron supports the square box, on the plan adopted in the monitor turrets. The vessel designed to carry the rotating square box with its light shell guns is a mere iron hull crammed with motive power, in order to insure a higher speed than that of existing iron-clad ships of war. The midship section is triangular, and the bow raking, as indicated by our sketch. (See Frontispiece.) The overhanging sides and deck are heavily armored.

Permit me to add, that I intend to make a formal offer, under certain stipulations, to furnish, at my own cost and risk, a swift screw vessel provided with a pair of 15 in. smooth-bore guns, and the necessary apparatus for sinking by submarine explosion, a vessel of the average draught of the iron-clad fleet of England, while such a vessel is being towed at the greatest speed possible, or performing whatever evolutions her owner may choose, with the distinct understanding that the attack shall not be made at a less distance than 500 ft. Accordingly, it has not been my purpose on this occasion, to enter into a full description of my new system of submarine attack. It may be well, however, to define clearly what the scheme is intended to accomplish. If a first-class swift iron-clad ship, say the Devastation, unassisted by other craft, will meet in open water a vessel constructed agreeably to the new system, it is contended that the latter will sink the breastwork

monitor in spite of her guns and impregnable armor, and notwithstanding evolutions designed to avoid the submarine missile.

THE STABILITY OF ARCHES.

Translation from "Exposé de la Situation de la Mécanique Appliquée."

Though arches have been constructed from very ancient times, no attempt was made to treat the problem of their equilibrium in a scientific manner until the last century. La Hire and Couplèt made the first attempts; the first complete theory is due to Coulomb. His results have been verified by experiments on models, of which those of M. Boitard may be specially mentioned.

The theory of Coulomb consists in expressing the equilibrium of each portion of the arch between the crown and the plane of any joint. Each of these portions is solicited by its own weight, by the weight of its load, and by the reactions of the contiguous parts of the arch. It is generally admitted that the pressure at the crown is horizontal; this supposes that the arch is symmetrical, and that it is loaded symmetrically with reference to a vertical plane through the crown. As the point of application of the thrust is not known, it becomes necessary, in discussing the conditions of equilibrium, to suppose it placed in succession at the highest, the lowest, and intermediate points. For the equilibrium of each portion of the arch thus isolated, it is necessary that there should be no tendency to sliding at the joint, and no tendency to rotation about either of the edges. These various conditions are expressed by several inequalities, in which the thrust at the crown and the ordinate of its point of application are involved. They should be formed for all the courses of voussoirs between the crown and each joint; and equilibrium will be possible if all these inequalities can be satisfied by a positive value of the thrust, and a value of the ordinate at the crown comprised between the corresponding limits of the thickness of the arch. If this determination is possible, it is still necessary to stability that the load at any point shall not exceed the limit of resistance imposed upon constructors.

The theory of Coulomb is complete; but it will not be found convenient in practice, if it is not subjected to a geometrical transformation, first pointed out by M. Mèry in an article inserted in "Les Annales" of 1840. This method depends upon the consideration of the curve or polygon of pressures. If the thrust at the crown were given in magnitude and position, it would be sufficient to compound it with the weight of a portion of the arch lying between the crown and any given joint, load included, in order to determine the reaction of the portion situated beyond the plane of the joint. The geometrical construction of this reaction would show whether there was a tendency to sliding or rotation; for there would be no tendency to slide unless the resultant should make with the normal to the joint an angle greater than the angle of friction between the voussoirs; and there would be no tendency to rotation so long as the line of mutual reaction passes through the joint, and not beyond it. Hence, if the thrust at the crown is given, the polygon of mutual reactions at the joints can be traced by compounding this thrust successively with the weights of the voussoirs and their loads. To insure equilibrium this polygon should cut all the joints in the arch, and should intersect them nearly at right angles. The locus of the points of intersection of the successive reactions, become at the limit, when the voussoirs are of infinitesimal thickness, the *curve of pressures*. Instead of referring to the actual planes of the joints, it is usual to divide the arch by vertical sections, in order to compound the thrust at the crown with the weights. This slightly alters the trace of the curve, but gives it a useful geometrical property, viz., that of representing the mutual reactions by tangents. The curve is then entirely analogous with funicular curves, in which the tension has a tangential direction. This property of the curve of pressures does not generally hold when the planes of separation of the various parts of the arch are inclined to the directions of the forces.

The curve of resistance is thus far defined, if its point of departure at the crown, and the direction and intensity of the thrust, are given. It is expressed by a differential equation of the third order, the integral of which contains three arbitrary constants. The curve may, therefore, be subjected to the condition of passing through three arbitrary points, and these are usually taken at the crown and at the springings. If the arch is symmetrical to a vertical plane through the crown, these three points may be symmetrical, so that the curve will be so. This is the most general case. The thrust at the crown is thus made horizontal. Very simple geometrical construction gives the magnitude of the thrust at any point; and the trace of the curve can be obtained by dividing the arch into small elements. When the curve is entirely comprised within the thickness of the arch, its distance from the intrados will not generally be constant at all points. The *joint of rupture* occurs where this distance is the least possible. It is here that the materials of the arch suffer the greatest pressure, and where rupture takes place if the distance between the curve and the intrados is too small. The joint of rupture opens along the extrados, and a crack extends across the spandril. If the curve of pressure approaches the extrados the joint tends to open toward the intrados.

These tendencies appear in all arches that can be observed, and the trace of the curve of pressure explains the facts which the old experimenters observed, but could not account for. Thus, in arches having the form of an arc of a circle, the joint of rupture is near the springing, and generally causes a crack in the spandrils in consequence of the opening of the joint at the extrados. In full semicircular arches there is a slight tendency to open towards the intrados at the crown, and towards the springing lines; while at an equal distance from these joints, at the joint of rupture, there is a tendency to open in the opposite direction.

The problem of the curve of pressures, as we have seen, is indeterminate; since the equation of construction contains 3 arbitrary constants in the general case, and 2 when the arch is symmetrical. This indicates that in a statical point of view, there are an infinite number of possible equilibriums; but one of these actually exists. If the real laws of molecular action were known, we should have the conditions necessary to determine this particular equilibrium. But we are arrested in this research by our ignorance of the actual laws. An attempt has been made to introduce into the problem considerations of the minimum value. The problem thus becomes determinate, but this determination is arbitrary, and there is nothing to prove that it is warranted. It seems to leave out of view special conditions of relative position, which though difficult to express in the calculus, still have a preponderant influence upon the distribution of pressures in the arch. M. Drouets has considered the problem from another point of view. In a fine memoir published in the year 1865, in "Les Annales des Ponts et Chaussées" he has discussed the results furnished by the method of M. Mèry, and, with the aid of ingenious geometrical considerations, has been able ot determine a curve of particular pressures, which satisfies the general conditions which make equilibrium possible. If it pass beyond the limits of the arch or show too great local pressures, it is certain that equilibrium is not possible.

Builders generally take for points of intersection the tiers superieur from the crown and the middle of the joint at the springing, a method which is expeditious, and in most cases sufficient.

The method of the curve of pressures, like that of Coulomb, from which it is derived, is a method of verification of equilibrium rather than a method of *invention* of the form of the arch. It has been of great service in reducing the thickness of arches and relieving them of a load which tended to destroy instead of strengthening them. But the forms authorized by long practice have not been modified by the influence of the new theories. An attempt has been made to determine by the calculus the best form to give to arches. M. Yvon-Villarceau has published a very interesting paper upon this subject, in which he delineates the lines of arches of equal resistance. The results of this analysis have not been introduced into constructions. M. Carvalho published in "Les Annales des Ponts et Chaussées," in 1853, a paper in which he endeavors to find the best form for the extrados of an arch of which the intrados is

given; and he determines the line, so that the curve of pressures of the loaded arch coincides with the curve of pressures of the arch without its load. The tables given in this memoir are useful in constructions.

In a practical point of view, the problem of the arch may be regarded as almost solved. The formulas given by Perronet are generally applied in determining the thickness at the crown and at the pieds droits. An inequality gives the inferior limit of thickness necessary to prevent tipping about the outer edge of the base; it is obvious that this does not increase indefinitely, as the height of the pied droit increases. Tables and empirical formulas more or less complex determine the principal elements of the construction. Builders, it is true, do not agree upon certain points; as, for example, upon the question of the change of thickness between crown and springing.

The equilibrium of arches when centred, is a problem still quite obscure. It was formerly treated by Couplet and afterwards by Perronet, who, in the construction of the beautiful bridges at Nantes and Neuilly, employed trussed centres of surprising lightness. The method of the curve of pressures now solves the problem in a more rational manner; but the complete determination of the strains developed in the centring, and in the arch, supposes the resolution of the problem of deformation of the centring, which requires a calculus very complicated and probably inextricable. Hence, engineers who deal with the question avoid the difficulty by reversing the problem. They admit that the centring makes the curve of pressures parallel to the intrados. This hypothesis makes known the action of the centring upon the arch, and may guide in the choice of forms to give to the carpentry.

THE SELF-PURIFICATION OF RIVERS.

From "The Engineer."

It is frequently asserted that history repeats itself, that events take place in recurring cycles, and that everything mundane tends to return to its normal condition. Upon this last hypothesis must, we think, be based the argument of those who have stated, and still maintain, that polluted and contaminated waters will, under certain circumstances, by a process of self-restoration, return to that state of pristine purity with which they were endowed by nature. This erroneous idea has long since been exploded in our editorial columns, and will receive its death-blow from the confirmation our views with respect to it have received in the recently issued Report of the Rivers' Pollution Commission. As we admitted then, we admit now, that a certain amount of purifying action is produced upon large volumes of running water by exposure to the air; but we emphatically now deny, as we denied then, that this can be justifiably termed a purification, or regarded even as an approximation to their restoration to their original purity, cleanliness, and sweetness. What was the assertion put forward by those who were interested in first polluting a river with sewage, and subsequently stating, in attempted justification of their conduct, that the contamination was but of a trivial and temporary nature? Their statement was, "that if sewage be mixed with twenty times its volume of river water the organic matter which it contains will be oxidized and comparatively disappear whilst the river is flowing a dozen miles or so." Were a million gallons of sewage to be discharged into the Amazon or the La Plata near their sources, it is possible that but little vestige of its injurious or offensive properties would remain by the time it was wafted to the shores of the Pacific. But the case assumes a different aspect when the scene is transferred to our own country and our own streams, and when the incessant daily discharge of sewage bears a proportion in volume to the contents of the channel of its reception which renders the process of self-purification of the latter a physical impossibility. To imagine that it could be otherwise would be tantamount to maintaining that a perpetual cause can produce only a temporary effect. There was a time in England, as there still is in all thinly populated and undeveloped countries, where purity was

the ocean, pollution the drop. Now the position of affairs is reversed; contamination is the ocean, purity the drop; and in the majority of instances the drop is so infinitesimal that it eludes the power of every agent that science, chemistry, and analysis can employ for its detection.

If we were asked, what are the causes of river pollution? our answer would be, everything that is capable of rendering water foul and contaminated. There is not an offensive, impure, or noxious substance that does not at some period or other find its way into a watercourse. There are, notwithstanding, several foreign ingredients in water that do not necessarily render it impure in the sense of injurious. Water may contain suspended and dissolved bodies which may render it unfit for drinking or domestic purposes, but which do not cause it to be either dangerous to health or offensive to the senses. Dismissing the terms pure and impure, and substituting those of polluted and unpolluted water, the chemical difference in their composition is the important fact to keep in view. A natural or unpolluted water frequently becomes turbid, or, to use the common phrase, dirty, from natural causes alone, but it is not thereby polluted. The contamination is only apparent, not real—only mechanical, not chemical—and can readily be removed by the employment of mechanical means solely. An unpolluted water may be recognized by being inodorous and tasteless, and by possessing a very faint alkaline reaction. It contains in 100,000 parts about 0.5 of carbon, and 0.1 of nitrogen, in the shape of organic matter, and is also endowed with the distinguishing feature of being incapable of putrefaction, although exposed to a summer temperature for some length of time in close reservoirs and vessels. Classing the numerous sources of river pollution under the two general heads of sewage and manufacturing refuse, it is the organic constituents of the former class that impart both the most offensive and most injurious properties to our streams and watercourses. Their amount of organic carbon is at once raised from 0.5 to 2.0, and of organic nitrogen to 0.75. An infallible sign that a stream has been polluted with sewage is the presence of chlorine, assuming always that its waters do not flow—like those of the Weaver, for example—in the neighborhood of salt deposits, either solid or fluid. To afford a good idea of the comparative state of purity to which the waters of the Thames near Hampton have been brought, it will be sufficient to refer briefly to the results of the analysis made by order of the commission of the Thames water and that of the Lancashire rivers. If the pollution of the Thames at Hampton be represented by unity, the maximum amount of that of the Lancashire rivers by organic carbon and organic nitrogen will be 6.5 of the former and 49.3 of the latter. It is rather curious that there is a greater degree of contamination in the streams of Lancashire in winter than in summer, although, for obvious reasons, it is not so apparent. This is one of those facts that would not be suspected, and probably would be strenuously denied until proved to be true by the unerring test of analysis.

Returning to the immediate subject of our article, namely, the statement that rivers—or, generally speaking, running waters—possess a remarkable power of self-recuperation, it must be borne in mind that hitherto this has been a bare assertion, never proved, or attempted to be proved in any manner whatever. It might be imagined that those who ventured upon so wholesale and sweeping an opinion would have taken some care to have at any rate a slight foundation upon which to erect so extensive a superstructure. Unfortunately for their argument, it was left to the commission to set the matter at rest one way or the other, as the members considered it of the highest importance that the truth should be known respecting a question which involved the health and welfare of all our large cities and towns. A favorable opportunity presented itself during the visit of the commissioners to the basins of the Mersey and Ribble for making the experiment, which was conducted with the same care and impartiality which characterize all their proceedings. The three rivers, the Mersey, the Irwell, and the Darwen, after being polluted to the last degree, have an average flow of 12½ miles without receiving any further contamination, although their respective volumes become considerably augmented by the accession of unpolluted affluents and tributaries. This disturbing cause must be taken into account when the results of the experiments are considered. Samples of the water at the

two extremities of the above distance were taken, and their composition ascertained by chemical analysis. The temperature plays an important part in the process. When it does not reach 64 deg. Fahr. there is very little effect produced by the flow upon the organic matter dissolved in the water. Taking the mean of the experiments upon these three rivers, the percentage reduction of the organic elements after the flow of 12½ miles was for organic carbon 10.98, and for organic nitrogen 8.58. In order to eliminate the element of uncertainty introduced into the calculation by the variable composition of the waters, which it should be borne in mind was all in favor of the self-purifying action, one volume of filtered London sewage was mixed with nine volumes of water. The mixture was carefully analyzed, and freely exposed to the light by siphoning it in a slender stream for several days from one vessel to another, the fall being three feet. It is not necessary to enter into the details of the conclusions arrived at. It is sufficient to state that the results indicate very closely the effect which would be produced by the flow of a river or stream containing 10 per cent. of sewage for 96 and 192 miles respectively, at a rate per hour of one mile. The percentage reduction of the organic carbon in the first distance would be 6.4, and of organic nitrogen 28.4. For the latter distance the corresponding figures are 25.1, and 33.3. As the temperature during this experiment was nearly 70 deg. Fahr., it demonstrates that the oxidation of the animal organic matters in sewage proceeds very slowly. It was also demonstrated by another experiment on the rate of oxidation of sewage, that supposing a river polluted with the above proportions of sewage received no further contamination for a distance of 168 miles, it would then lose about 62.3 per cent. of its injurious and offensive properties. Is there any river or stream in England which could fulfil those conditions? Granting that only one discharge of sewage took place, it might be safely inferred that there "is no river in the United Kingdom long enough to effect the destruction of sewage by oxidation."

In addition to the conclusive results arrived at by the commissioners, it was proved by the evidence of landowners situated eight or ten miles down the stream from the town where the pollution originated that the water was "utterly foul, slimy, thick, and seething." If we examine into the cause of the belief by many persons of the self-purifying power of running water, it will be found in the identity they suppose to exist between clear and pure water. A stream will, during its flow, deposit a large proportion of the grosser and visible impurities which are held simply in mechanical suspension. The turbidity of it, or, in plain language, its dirtiness, will thus be plainly decreased; but the amount of the *dissolved* impurities will remain the same. The water will *look* cleaner, but chemically will be as dirty as before. But, although the stream deposits by subsidence the mud or other substances mechanically suspended in it, they are not by these means rendered innocuous. On the contrary, in flood times and during summer this deposited sediment becomes stirred up and putrescent, and when collected proves to be "disgustingly offensive." After the facts laid before them, our readers are fairly warranted in dismissing all idea of the self-purifying powers of running water, not, perhaps, as Sir Benjamin Brodie observed in his evidence, as "absurd," but as practicable only under conditions the fulfilment of which is impossible.

QUICK PASSAGE TO BOMBAY *via* THE SUEZ CANAL.—The Bywell Castle, steamship, belonging to Messrs. Palmer, Hall & Co., arrived at Bombay on the 16th ult., after a passage of 35 days from the Thames, including 3 days occupied in passing through the canal.

SUEZ CANAL.—Direct steam communication between Holland and her Eastern dependencies (Java, Sumatra, Sunda Islands, etc.) *via* the Suez Canal, is being organized at Amsterdam, under the honorary presidency of Prince Henry of the Netherlands, brother to the King of Holland.

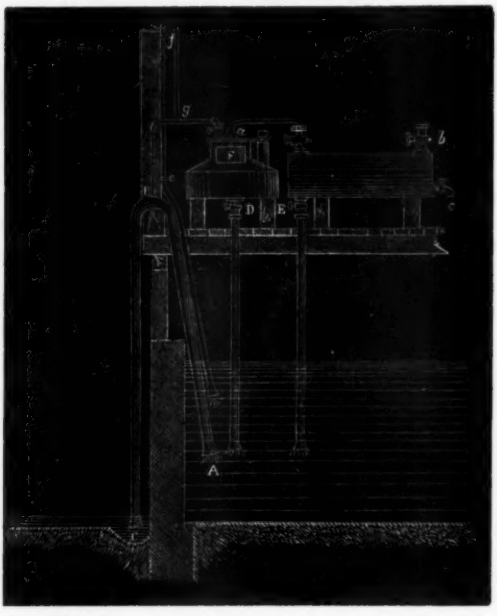
THE elevated railway in Greenwich street, in this city, is (as usual) announced to be about ready for public patronage.

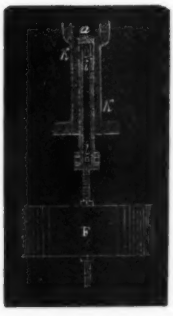
SIPHON AND SUCTION PUMPS.

Translated from "Les Mondes."

M. de Lagillardais has invented an apparatus which utilizes in many ways the simple phenomenon of the discharge of liquids, or of liquids mixed with gas, through tubes bent in a vertical plane like the ordinary siphon.

The pressure determines the direction and the continuity of discharge in these tubes. A discharge being induced in the first siphon, will cause a suction of the air contained in a tube communicating with its top; this again will set the second siphon in action. It is obvious that by means of a combination of siphons and of





prises d'air, which cause the *pulverization* of the liquid in the ascending brandies, the pressure can be regulated.

Of the two siphons referred to, the first takes the name of suction siphon, with reference to the second, which, because its effect is like that of the common pump, is called the siphon pump. The first siphon acts as a motor to the second; it makes use of a fall of water to produce the suction which raises and carries the liquid over.

The *priming* (*amorçage*) of the suction siphon is affected by means of an apparatus called the *priming reservoir*.

A *primer*, a suction siphon, a communication betwen suction siphon and pump siphon, *ajutages*, are the elements employed by M. de Lagillardais.

The figure (A) is an illustration of the apparatus.

A suction siphon, using the head of a certain quantity of falling water which passes through B C to a lower level, produces a suction in the pipe *e*, and finally a discharge from the receiving reservoir through the orifice *c*. The details may be easily understood from the figure. The priming reservoir is set at the common level of the top B, and of the receiving reservoir; it communicates with the race by a vertical tube provided with a stop-cock D. This priming reservoir communicates with the top of the siphon B and with the receiving reservoir. Suppose this to be full of water; by opening its connections with the race and with the suction siphon, the others being closed,

the priming of A, B, C, will be caused by the fall of water. As soon as the suction siphon is in action, its communications will cause action in the priming reservoir, which will be ready at any time to renew its action after the operation has been interrupted by any cause; and also to renew the action in the receiving reservoir. A manometer, *c*, *f*, *g*, will show the force of suction. The communications of the different parts of the apparatus require regulation. This is automatically accomplished by a valve, shown in detail in Fig. B. F is a float acting upon a valve *a*, connected to it by a hollow stem which guides the socket *k*. At *i* are the orifices regulating the admission of air into the primary reservoir.

In Fig. A, the suction siphon and the siphon pump dip into the same layer, so that a part of this layer is lifted at the expense of the other, which acts as motive force. Generally speaking, the priming reservoir, the suction siphon and the pump siphon, when communicating with their upper connections, correspond to distinct layers of the liquid. The levels of the priming reservoir and of the tops of the siphons may also be independent.

In the most complex case, as represented in Fig. A, in which the reservoir is above the priming reservoir, it would be necessary to fix a pulverization *ajutage* at the bottom of the ascending tube of the receiving reservoir, and to adjust the suction pump accordingly.

The applications to which M. de Lagillardais proposes to adapt this apparatus are numerous. He mentions, in particular:—

The priming and the maintenance of the action siphons employed in the drainage of liquids; especially siphons discharging a basin at high tide.

2. The elevation of liquids and all kinds of drainage.

3. The production and maintenance of a vacuum; and as a consequence the freezing, condensation, and evaporation of liquids in a vacuum.

This apparatus is new and ingenious. It seems to be available in the utilization of those natural forces which so often remain unproductive.

UNION PACIFIC ENGINEERING.

From "The Iron Age."

We are indebted to Gen. G. M. Dodge, late Chief Engineer of the Union Pacific Railroad, for a copy of his Report, December 1, 1869, to President Ames, giving a connected history of operations in his department, with reports of Chiefs of Parties during the years 1868 and 1869.

We preface an abstract of the most valuable portions of the Report, with a sketch of the

EARLY SURVEY,

and Mr. Dodge's connection therewith. In 1853, Henry Farnham and T. C. Durant, who had the contract for building the Mississippi and Missouri road (now the Iowa division of the Ch., R. I. & Pac.), instructed Peter A. Day to investigate the question of the proper point for that road to strike the Missouri river, to obtain a good connection with any road that might be built across the continent. General Dodge was assigned to the duty, and surveys were extended to and up the Platte Valley, to ascertain whether any road built on the central or then northern line would follow the Platte and its tributaries over the plains, and thus overcome the Rocky Mountains. Subsequently, under the patronage of Mr. Farnham, General Dodge extended the examination westward to the eastern base of the Rocky Mountains and beyond, examining the practicable passes from the Sangre Christo to the South Pass; made maps of the country and developed it. The practicability of the route, the singular formation of the country between Long's Peak, the Medicine Bow Mountains, and Bridger Pass, on the south, and Laramie Peak and the Sweetwater and Wind River ranges, on the north, demonstrated that through this range the road must eventually be built. He reported to Mr. Farnham, and through his and his friends' efforts the prospect for a Pacific road began to take shape.

In after years surveys were extended through the country previously explored, and its capabilities for the building of a railway to the Pacific fully demonstrated.

In doing this over a country covering a

width of 200 miles, and on the general direction of the 42d parallel, some 15,000 miles of instrumental lines have been run, and over 25,000 miles of reconnaissances made.

DIFFICULTIES ENCOUNTERED.

In 1863 and 1864 surveys were inaugurated, but in 1865 the country was systematically occupied; and day and night, summer and winter, the explorations were pushed forward through dangers and hardships that very few at this day appreciate, as every mile had to be run within the range of the musket. Numbers of our men (says Mr. Dodge), some of the ablest, were killed ; and during construction, stock was run off by the thousand; and as one difficulty after another arose and was overcome, both in the engineering, running and construction departments, a new era in railroad building was inaugurated. Each day taught lessons by which they profited for the next, and the advances in the art of construction were marked by the progress of the work ; 40 miles of track having been laid in 1865; 260 in 1866; 240 in 1867, including the ascent of the Rocky Mountains, 2,235 feet above the ocean; and during 1868, and to May 10, 1869, 555 miles, all exclusive of side and temporary tracks, of which over 180 miles were built in addition.

The first grading was done in the autumn of 1864, and the first rail laid in July, 1865. When one looks back to the beginning at the Missouri river, with no railway communication from the east, and 400 miles of the country in advance without timber, fuel, or any material to build or maintain a road, except the sand for the bare road-bed itself, with everything to be transported, and that by teams, or at best by steamboats, for hundreds and thousands of miles ; everything to be created, with labor scarce and high, we can all look back upon the work with satisfaction.

FINAL LOCATION.

Its location has been critically examined, and in regard to the correctness of the general route, no question is ever raised ; and even in the details of its location, 730 miles of which were done in less than 6 months, it has received the praise of some of the ablest engineers of the country. Its *defects are minor ones,* easily remedied, and all the various commissions have given the company due credit in this particular.

In January, 1858, Mr. Dodge received instructions for that year. He was to finish the location to Green River by June 1, to Salt Lake Valley by autumn, and before winter, to develop the country west of Salt Lake. He made ample arrangements to accomplish this. James A. Evans, in charge from Laramie to Green River, having four parties who took the field in March, the snow being deep, and Mr. Blickensderfer, with three parties, to locate from Green River to Salt Lake, who took the field in March. Mr. Evans completed his survey by May 2, and Mr. Blickensderfer his in July, both before the time set.

In April, the Vice-President informed Gen. Dodge that "he desired to cover the road with men from Green River to Salt Lake within one month, and to Humboldt Wells in three," and notwithstanding no intimation had been given, and no arrangement made to carry out such a programme, he succeeded in completing the location over the difficult work, and over a large portion of the light work, before the contractors could get on the road. The forcing of the parties forward so fast, over so difficult a country, gave no time to review lines, and re-examine or re-run them on the ground. West of Green River and down Bitter Creek there was no preliminary line standing as a guide, the surveys by Evans and Reed in 1864 being obliterated. The locating engineers lost no time by any party ; but worked day and night, even to the full seven days of the week.

BROWN'S PASS TO GREEN RIVER.

From Brown's Pass, latitude 41 deg. 50 min., to Green River, latitude 41 deg. 38 min., the line is so direct that on the ground it does not increase the distance over an air line 5 miles in more than 200, and in the measurement by longitude the increase is not perceptible. This location has no grade to exceed 65 ft. per mile ; no curvature to exceed 6 deg., and in the detailed location its per cent. of curve line is one-sixth, of tangent five-sixths.

In the Rock Creek country, the contour of the ground has been too closely followed, and too much curvature is used, a matter easily remedied hereafter. With this and other slight exceptions, the location

is fair, the grades easy, curvatures light, alignement very direct, the water-ways ample, and the resources of the country, with its coal beds, made available. The grading, mostly in embankment, is 1 to 2 ft. higher than appears necessary in the summer, so to avoid the snows of winter, the economy of which has already been demonstrated by the diminished ability of that portion to obstructions from snow. The location down Bitter Creek is a good one—bold, direct, and made with an intelligent view of the commercial value of a line, as determined by alignement and grades, as well as mere cost of construction. The question of a supply of water between North Fork of Platte and Bitter Creek received serious consideration in 1867. The running of construction trains was difficult, most of the water having to be taken from North Platte; yet time brought a fair supply at all the wells, and now trains run without detention.

The alkali and soda-water district extends from the Laramie to Green River, but they take water from mountain streams and springs, from the Laramie to North Fork of Platte, throwing all the bad water on one division, Rawlins to Green River.

GREEN RIVER TO MOUTH OF WEBER.

Gen. Dodge's examinations of 1867 had satisfied him that the true route was north of Salt Lake. It was desirable to get a more direct line than by way of Weber Valley. Of all the passes over the Wasatch that at the head of Blacksmith Fork alone remained, and it was considered important to definitely settle its character.

Mr. Hodges' examinations determined the impracticability of the Blacksmith Fork route, which would have saved 40 miles and given a much better direction.

A careful examination of the located line, as well as of all the other lines surveyed, either then or afterward by the construction department, convinced Gen. Dodge that the line adopted is superior to any other. No other compares with it in a commercial value; and in avoiding obstructions from snow, no other is equal to it.

Considering the character of the country, the

LINE FROM PIEDMONT TO PROMONTORY

may be considered a remarkable one, crossing three ranges of mountains, passing for 60 miles through the gorges of the Wasatch, and descending from an elevation of over 7,000 feet above the ocean to one of less than 4,300. This line of *two hundred miles in length*, in the magnitude of the work required, does not much exceed the 200 miles eastward from Piedmont, comprising the valleys of Black's Fork, Green River, and Bitter Creek. Nature did much to render it comparatively easy to overcome the great obstacles which had been looked upon as the most formidable barriers to the road, and, by a skilful location, the work per mile in cubic yards was rendered very light, and should not, under ordinary circumstances, have cost over 25 per cent. more per mile than for the same distance east of the rim of the basin. But the cost was often doubled and even trebled and quadrupled. This is accounted for by the untoward circumstances under which it was pressed to completion, and not by any large amount of work per mile, or peculiarities, location, or its mountainous character.

MOUTH OF WEBER TO HUMBOLDT WELLS.

The best line for grades and curvatures would have been to cross Bear River arm of the lake, eight miles in width, but they found from 12 to 22 ft. of water, a permanent rise of 9 ft. since 1863. This forced them to adopt the line north of Bear River Bay, substantially that run in 1867 for the Central Pacific Railroad.

The prominent features are the mud flats skirting the north of the desert; the crossing of Promontory Point; the passage of a spur of Raft River Mountains by Red Dome Pass; turning of Raft River Mountains proper by Rosebud Creek; passage of Omber or Pilot Peak range by Surprise and Passage Creeks; the climbing of Toano Mountains, 1,270 ft. above desert, by a continuous 60 to 65 ft. grade; and the passage of these mountains by Ives' Pass; the Pegnoss Range by Pegnoss Pass; Cedar Range by Cedar Pass, and of the Humboldt Mountains by that natural depression at the head of the valley of the Humboldt, at Humboldt Wells.

There had been so much said about building over the mud flats that a thorough investigation was made. Where water stood on them it was found that they be-

came harder, and 2 ft. below a *clayey subsoil existed*, capable of sustaining a roadbed. Below, quicksand was often met; but with a high bank, giving proper drainage, a bed could be properly sustained, if properly ballasted. He therefore crossed the flats where alignement or grade demanded it.

Promontory Point, the most difficult summit to make, and where the most intricate line, the heaviest work, the highest grades, and the sharpest curves occur, is a bold backbone running north and south, 600 ft. high, with scarcely 4 miles of direct ascent from the east, and 12 of descent on the west, devoid of natural ravine or watercourse. To approach the summit the line has to cling to the rough sides of the ridge, and gain distance by running up Blue Spring Creek Valley, and winding back again on its opposite side. Lines of 70, 80 and 90 ft. grades were traced on the western slope, and the 80 and 90 ft. were so nearly equal that it required a careful adjustment of each, and close estimate, to determine which was entitled to the preference. Finally, the 80 ft. line was adopted, and considerably improved. The 6 miles on the east slope has heavy work and a few 6 deg. curves as a maximum, and is by far the most difficult portion of the line west of Weber Canon. After surveying a number of lines they made a location over it. Subsequently, they adopted the 83 ft. grade line.

Grading at this point was not commenced until Feb., 1869, and from the material to be moved, with the track rapidly approaching, it became necessary to work night and day, and increase teams without regard to economy. Eight hundred thousand yards of material were taken out by contractors in the early stages, costing $623,000; while 178,000 yards, under the day system, when working night and day shifts, cost $618,000. This fact shows that the company spared neither money nor labor to gain time in the final completion of the road. The descent on the west is made with 53 ft. grade, and light work. The mud flats are crossed, and Monument Point reached at an elevation of about 4,300 ft. The western shore of the lake, near Monument Point, is bold, where boats could easily land.

Red Dome Pass, 600 ft. above the lake, is ascended with a continuous 65 ft. grade, no curves to exceed 6 deg., and very light work. The descent is slight for 20 miles to Terrace Pass, from which the line, descending to the level 30 miles, skirts the north rim of the great desert. This 30 miles is a tangent almost the entire distance. It there enters the valley of Surprise Creek, crosses it with 12 miles tangent, and makes the ascent of the Toano Mountains with a 60 ft. grade, probably the most remarkable ascent on the continent, as 900 ft. of elevation is made with a continuous 60 to 65 ft. grade of 14 miles in length, with no cut or fill to exceed 10 ft., and no curves to exceed 4 deg.

The remarkable feature of these mountains is their long foot slopes, with a contour so uniform that almost any elevation can be obtained without heavy work. Toano Mountains are passed by Ives' Pass, from which the line diverges to the north, down a tributary of Thousand Springs Valley, with easy grades, to the intersection of Pegnoss Creek, which is ascended to the summit of Pegnoss Range at Pegnoss Pass. The line then makes almost directly west into the valley of Independence Creek, from which it rises to Cedar Pass, and then descends by clinging to the long slopes with 60 ft. grades, to Humboldt Wells, where the location ends at an elevation of 5,587 ft. above the sea. The line is remarkably cheap for such a mountainous country, passing 6 ranges at right angles in 232 miles.

It is remarkably direct, will be free from snow, passes through a country a great portion of which is susceptible of cultivation, well enough timbered with cedar and pine sufficient for all practicable purposes, with mountain streams, affording a fair supply of water.

North of the desert the valleys are heavily bedded with grass, and the hillsides covered with bunch grass of the finest quality. The country allows a very good alignement, avoiding extreme curvature and no grade over 65 ft., with very light work except on Promontory.

ROUTES AROUND SALT LAKE.

General Dodge became satisfied that the northern was the true route. As the company desired a comparison of the two, he *examined both personally*, and ran several instrumental lines on the south side, full details of five being obtained, but one of which required comparison with the north line.

The south line would connect with the main line just west of Ogden, from Humboldt Wells 301.3 miles, as against 225 miles by the present road. This line avoids the Promontory Mountain with its heavy grades and work, but, instead of 5 miles of 80 ft. grade, has three times as many miles over Goshoot Pass with 90 ft. grade, and nearly three times the amount of work passing the Toano Mountains.

This comparison shows conclusively the superiority of the northern over the southern line, being shorter by 75.15 miles, having less ascent and descent, and a less elevation to overcome and less curvature. The total cost of the north line is about $2,500,000 less than that of the south line would have been, besides the difference as a purely engineering question.

MATERIALS ON THE LINE.

Timber and Stone.—Near the heads of the watercourses in the mountains a sufficiency of timber within available distances can always be found for the ordinary repairs of the road in replacing ties for buildings, and for other local uses, but not of a quality suitable for large or important railway structures. Good building-stone will be more difficult to obtain, as much supposed to be durable, from the presence of some element yet unknown, proves to be, when exposed to the atmosphere, entirely unreliable and useless. There are, however, some quarries of good stone on the road.

Ballast.—The road-bed is very largely composed of sand, gravel, and loam, which of themselves sustain a track well, and the climate is so dry that neither the autumnal frosts nor the spring thaws affect the ground materially, and the track can be sustained with an expenditure much below the average of other roads.

IMPROVEMENTS.

Since the junction of the two tracks a large force has been kept at work, bringing the road up to the Government standard. Between Wasatch and Ogden all the temporary bridges over large streams have been replaced with permanent structures, and the road has been fully ballasted. The temporary tracks are all abandoned. Between Bryan and Wasatch a heavy force has been preparing the foundations and putting in the masonry for permanent bridges over the large streams, and the superstructure is all on the ground.

Large gangs have been at work on the road-bed; the banks are widened, the cuts sloped, and now very little remains that is of pressing necessity.

All grades ascending both eastward and westward can be reduced to 60 ft. per mile, except those over the three mountain ranges, should the commerce of the road demand it; and, in many cases, by judiciously taking out cuts for ballast where sharp curves now occur, the curvature can be much ameliorated.

MISSOURI RIVER BRIDGE.

The Missouri River is now the only obstacle between the Atlantic and Pacific, and as the transfer is now made it is an unnecessary tax and annoyance to travel and traffic. The U. P. R. should receive all passengers and freight on the east bank, placing the transfer in the hands of one company and under one management.

The U. P. R., by law, has its terminus on the east bank, and its charter has been so drawn as to give it all the rights and privileges necessary to do this transfer by itself, or an agent, or by contract.

It is an unnecessary tax to force four competing roads to each put in boats to do a business that one road can do for all four, and the cost of maintaining these four tranfers is sufficient to prohibit in a close competition a large amount of through traffic.

The completion of the bridge at an early day is a necessity, and our experience is now such that we can push the work at almost any rate of speed directed.

To avoid filling our columns disproportionately, we have prepared the following abstracts of several valuable tables contained in the Report:

BUILDINGS, SIDINGS, ETC.

Of the 150 points on the road at which these buildings have been erected, 100 are stations, and 50 have merely section houses, tool houses, windmills, etc. The structures are as follows:

Freight Houses	12	Circular Houses	10
Tanks	51	Iron Houses	4
Turn Tables	11	Paint Houses	3
Coal Houses	17	Storehouses	15
Tank Houses & Tanks	27	Coach Houses	1
Engine Houses	8	Tool Houses	197
Stationary Houses	9	Section Houses	199

Watch Houses	6	Paint Shops	2
Tank Master Houses	2	Founderies	4
Bridge Master Houses	1	Telegraph Offices	10
Tank Engine Houses	4	Civil Engineers' Offices	2
Baggage Houses	2	Tank Master's offices	1
Warehouses	7	Offices	15
Pump Houses	31	Depots	72
Battery Houses	5	Stables	2
Ice Houses	5	Sheds	1
Oil Houses	9	Sawmills	1
Bridge Houses	3	Burnettizers	1
Wood Pile Houses	2	Hotels	6
Agents' Houses	8	Hotel Wings	1
Machine Shops	6	Sleeping Rooms	7
Blacksmith Shops	9	Company Stores	2
Car Shops	3	Woodsheds	1
Repair Shops	3	Windmills	50
Car Repair Shops	1		

The amount of side track is 472,547 ft.—89.5 miles; the total length of line, 1,085.875 miles. Of this total

THE GRADES

are as follows:

		Miles.
Level		200.47
0 to 20 ft.	Ascent	325.17
	Descent	116.03
20 to 40 ft.	Ascent	162.498
	Descent	112.229
40 to 60 ft.	Ascent	49.835
	Descent	48.817
60 to 80 ft.	Ascent	41.889
	Descent	14.576
80 to 90 ft.	Ascent	.....
	Descent	14.491
Total Ascent, ft.		13,087.34
Total Descent, ft.		9,336.88

THE ALIGNEMENT

is as follows:

Degree.	Radius.	Miles.
¼	34377	2.67
½	22918	0.49
¾	17188	0.20
1	11460	22.514
¾	7639	1.487
1	5730	44.315
1½	3819	2.836
1¾	3437	2.47
2	2864	38.467
2½	2292	4.105
3	1910	30.343
3½	1637	2.336
4	1432	26.422
4½	1273	0.952
5	1146	12.971
5½	1042	0.53
6	955	5.292
Length of Tangent		887.458
Length of Curve		198.420
Degree of Curvature, right	11,698.39	
Degree of Curvature, left	12,446.22	
Total Curvature		24,144.61

BRIDGES, CULVERTS, AND TRESTLE-WORK.

The total number of these structures was, at the date of the Report, 1,402,—aggregating 69,281½ ft. or 13-$\frac{1}{10}$ miles. Of these, 41 were Howe truss, 10,070 ft.; 10 strain beam bridges, 420 ft.; 3 Post truss do., 485 ft.; 2 Post combination do, 890 ft.; 376 trestle, stone abutments, 30,385 ft.; 74 trestle, on pile, 6,228 ft.; 223 pile bridges, 16,731 ft.; 40 stringer do., 591 ft.; 49 stone arch culverts, 571 ft.; 373 stone box do., 817 ft.; 20 wood box do., 37½ ft.; 59 open stone do., 372 ft.; 132 open wood do., 1,684 ft.

CONDENSED HISTORY OF STEAM.—About 280 years B. C., Hiero, of Alexandria, formed a toy which exhibited some of the powers of steam, and was moved by its power. A. D. 450, Anthemius, an architect, arranged several caldrons of water, each covered with the wide bottom of a leather tube, which rose to a narrow top, with pipes extended to the rafters of the adjoining building. A fire was kindled beneath the caldrons, and the house was shaken by the efforts of the steam ascending the tubes. This is the first notice of the power of steam recorded. In 1543, June 17th, Blasco D. Garay tried a steamboat of 209 tons with tolerable success, at Barcelona, Spain. It consisted of a caldron of boiling water, and a movable wheel on each side of the ship. It was laid aside as impracticable. A present, however, was made to Garay. In 1650, the first railroad was constructed at Newcastle-on-Tyne. The first idea of a steam-engine in England, was in the Marquis of Winchester's "History of Inventions," A. D. 1663. In 1710, Newcomen made the first steam-engine in England. In 1718, patents were granted to Savery for the first application of the steam-engine. In 1764, James Watt made the first perfect steam-engine in England. In 1763, Jonathan Hulls set forth the idea of steam navigation. In 1778, Thomas Paine first proposed this application in America. In 1781, Marquis Jouffroy constructed one in Saone. In 1785, two Americans published a work on it. In 1789, William Tymington made a voyage in one on the Forth and Clyde Canal. In 1802, this experiment was repeated. In 1782, Ramsey propelled a boat by steam to New York. In 1783, John Fitch, of Philadelphia, navigated a boat by a steam-engine on the Delaware. In 1793, Robert Fulton first began to apply his attention to steam.—*The Iron Age.*

THE STRENGTH OF ROLLED SECTIONS OF IRON.

From "The Engineer."

There is obviously a limit at which it becomes more economical to employ a solid section of rolled iron than to "build one up," as it is technically termed; but where that limit is to be found engineers are by no means agreed. Some even contend that under all circumstances a built-up section is to be preferred, while others, on the other hand, advocate the adoption of the "joist" under conditions of span and load for which it is certainly not adapted. Without the slightest intention of attempting to act as an arbitrator in the matter, it may be stated that there is an ambiguity attending the calculation of the strength of all rolled sections of iron from which the built-up type is comparatively free. Let us select as a commencing example a rolled joist and a built-up one having the same depth, span, and the same net area of bottom flange. If the breaking weight be calculated, and the same constant used, the two beams will be equally strong; but what a relative disproportion exists in the two webs! Owing to the practical exigencies of the rolling process it is impossible to make the web of the one approach in thickness, or rather thinness, to that of the other. It is also true that, in instances in which the span and load are small, the web of a plate beam must, at least in the central portion, be in excess of the theoretical shearing strain upon it; but the discrepancy is slight compared with that of a rolled joist under similar conditions. Supposing, however, that we have an example where the web of the built-up or plate beam is not more in excess of its theoretical requirements than what always attends the reduction of theory to practice. In the rolled beam intended for the same weight and span the area of the web will very much exceed that of the plate girder. How is this increase of area to be allowed for? The thicker the web evidently the greater the strength of the beam, although the increase of strength will be nothing like what might be perhaps anticipated. It must not be forgotten that there is very little use in accumulating material at or near the neutral axis. In other words, it is not in the web, but in the flanges, the metal is most serviceable, since its moment of resistance is in direct proportion to its distance from the neutral line. Theoretically, the web is regarded as imparting no element of strength to the girder, but has its influence confined to two points. The one is to possess sufficient stiffness to keep the flanges apart, and the other to be sufficiently strong to support its own shearing strain. Compared with the strain upon the flanges, this duty is very light, as will be seen by selecting an example. Suppose a girder to have a span of 100 ft., a load per foot run of one ton, and a depth of 8 ft. For a girder of this size the web would be double, and the maximum normal strain upon each end at the abutments would be 25 tons, whereas that upon either flange would be 156.25 tons.

It might be argued that a rolled joist may be regarded as a solid beam with a part cut out, and so it might; but this view lessens neither the ambiguity nor uncertainty of the calculation. Some engineers do treat rolled joists in this manner, but there are no data in theory nor experiments in practice to prove the conclusiveness or the soundness of such treatment. It is impossible, with the present limited and scanty information we possess, to be able to estimate what proportion of the area of the web acts as a solid beam, and ought to be estimated as such. Evidently the whole area ought not to be included in the calculation, for a part of it is absolutely necessary to maintain the relative connection between the flanges, and it is on that assumption that their own strength is estimated. If two separate calculations be made, one for the strength of the flanges, and another for that of the web, and the total net area of the web be included in the latter, then part of it is estimated twice over. It is not to be understood that it has actually been included numerically in the formula, but that it has virtually been allowed for. Should it be argued that it has not, then we have the astonishing problem of a flange of a beam supporting a heavy strain without any web at all. The whole difficulty arises from the fact of considering a rolled joist as a girder of compound parts, in which the total strength consists of the separate resistances of the flanges and web.

That they do mutually assist one another there is no doubt; but it is impossible to draw the line of demarcation, and to tell where the action of one ceases and that of the other begins. The advocates of the solid-sided or plate system of girder allege that the continuous web relieves the flanges of as much as one-sixth of their longitudinal strains; but this is doubtful. Without venturing upon such extreme statements, the part played, or supposed to be played, by the web, when of extra thickness, in assisting the flanges, might be allowed for by adding some of its area to that of the bottom flange in the formula, and thus virtually calculating the strength of the beam as if it had a bottom flange of a greater area. Unfortunately, the unknown quantity in this simple equation is the amount of web area that should be included in it; and as this must be known before the equation can be solved, the solution is, practically, not determinable.

When once a rolled beam is considered in the light of a simple flanged girder, all uncertainty respecting its ultimate strength vanishes. We know that its strength can never be less than that calculated upon the above assumption, since the extra thickness given to the web may strengthen but can never weaken the flanges. Until some more reliable data and information is at our disposal the influence of the additional thickness of the web of a rolled beam may be cautiously allowed for by assuming a higher constant than that used for the plate or lattice girder. The value of this constant might be safely taken to be equal to 80, which supposes that no flexure can possibly take place in the web —a condition that cannot be asserted to be always fulfilled in either a lattice or a plate girder. The effect of any appreciable deflection or yielding taking place in the web upon the flanges is to bring a transverse strain upon them, which they are not adapted to resist; and, consequently, whenever there is a chance of this, the constant must be lowered in value, or the breaking weight, and thence the actual weight or working load, will be in excess of the strength of the structure. Some reliable experiments are really required, carried out with a view to determine the actual difference in the breaking weights of rolled and built-up sections of iron, so that the value of the additional thickness in the web might be accurately ascertained. The span, load, depth, and net area of flanges being the same, the discrepancy between their breaking weights, if any, could always be allowed for by deducing the corresponding constant.

ON SHIP BUILDING.

From "The Scientific Journal."

At a meeting of the institution of Naval Architects of London, on the 17th ult., a paper was read on the "Load-draughts of Merchant Ships," by Mr. W. W. Rundell. The proper draught for a merchant vessel, said the author, is not a question to be determined in the first place by science, but by experience. Science may lend her aid in generalizing and defining the results of experience, but must unhesitatingly accept the dicta of those whose position and practice make them the real arbiters of the question. The naval architect and ship-builder must bow, like others, to the decision of these experts. The load-draught cannot be arbitarily fixed by the naval architect. Lloyd's rule, three inches to the foot depth of hold, or the scale of the Liverpool underwriters, may be quoted; but these blind no one Lloyd's rule was a suggestion only, and it was made when iron ships were just being talked of, and when few ships except East India men, exceeded 700 or 800 tons, and it has never been recognized by Lloyd's Committee, except as an approximate guide for the loading of certain classes of vessels. The Liverpool scale is intended only for first-class vessels, and is subject in all cases to the judgment of the surveyor, who is influenced by the age and class of a vessel, its general proportions, the intended voyage, the nature of the cargo, and other circumstances favorable or otherwise. The experts who practically rule in these matters are certain surveyors more or less intimately connected with the underwriting bodies, and who, if not practically appointed by ship owners, have secured their confidence.

Their great experience enables them to judge very closely as to the draught of water at which a ship begins to damage her cargo or become otherwise unsafe. Wooden vessels are now passing away, and iron sailing ships are being largely superseded by steamers. Iron sailing vessels will in future be chiefly employed in long voyages, and new ones will probably be of large size. As regards iron vessels, therefore, considerations depending on their age, the nature of the voyage, the season of the year, as affecting their load-draught, may be omitted nearly altogether. Considerations arising from the kind of cargo may also be omitted, as it is generally acknowledged that with proper care, and by incurring the expense necessary for making good stowage, any proportion of dead weight may be safely carried. There remain only those conditions which relate to form and proportion, and these, I submit, are sufficiently represented by adopting the customs measurements and registered tonnage. The suggestion that $\frac{3}{10}$ths of the whole displacement is a proper proportion for buoyancy was made years since by Mr. J. Jordan. The author then proceeded to refer to various tables bearing on the subject of his paper; and alluding to the requirement of more free sides for large wooden ships than for small ones, he said that the reasons assigned for it were not applicable to iron ships. Large iron ships can be as strongly built as small ones. There can be little objection to the $\frac{3}{10}$ths displacement scale for ascertaining when a sufficient quantity of cargo has been placed on board a vessel. But it makes no allowance for extreme length, or for the length and character of the waves she may encounter. The surveyors state the extreme length in proportion to a vessel's other dimensions, must be considered; but, so far as I am aware, they have not defined to what extent. Like the surveyors, I have not come to any difinite conclusion on the subject, but wait for better instructions. Like other scales, which point out with more or less exactness what is the proper load-draught for a vessel, they leave us in ignorance as to what amount of departure from it will render a vessel relatively unsafe or practically unseaworthy. After some observations as to the desirableness of some mode of ascertaining the point at which a ship becomes dangerously laden, the author concluded by the following practical suggestion: Let a round spot 9 in. in diameter, be conspicuously painted on every vessel over 300 tons register on each side, midships, at a point through which a horizontal plane would pass, which would cut off the upper one-fourth of the vessel's registered tonnage when she is on an even beam. This would be useful in indicating pretty accurately when the $\frac{3}{10}$ths of the whole vessel are out of water. In vessels of about 500 tons this mark should be fully its own diameter above water. In vessels of 750 tons it would be two diameters above water, in larger ships two and a half diameters. Here one kind of instrument would be needed to make the observation. If the spot were very near the surface of the water the ship would certainly be very fully laden; if it touched the water she would be very deeply laden; if immersed or out of sight she would be dangerously laden. This would not hurt the ship-owner in any way. The proposed mark would indicate a fact, not an opinion.

Mr. Laport was of the opinion that no fixed rule could ever be satisfactorily used and applied to vessels of all descriptions. The strain upon a vessel in a sea way depended a great deal more upon the disposition of the cargo within the ship than the actual weight in reference to the capacity of the ship and amount of free board. An instance came to his notice in which a vessel was about to sail, when the captain discovered she was not laden to the proper line, so as to develop her best sailing capacities. He therefore placed 7 tons of lead in the extreme part of the stern, and so brought her to the right position. When such a vessel got to sea those 7 tons of lead would produce a blow as of a tremendous hammer at the stern of the ship, and would almost be destructive of an old or improperly constructed vessel. Another thing which would militate against the adoption of any ordinary rule was that in some ports through which a river runs, vessels were borne by fresh water, which weighed 62 lbs. to the cubic foot; but at sea the water weighed 64 lbs. to the cubic foot. Thus if an arbitrary rule would unjustly press upon ships loading in such a port as Sunderland, as compared with Liverpool, where the buoyancy of the water was greater, the discharging part of the cargo

when a vessel was overloaded was not always beneficial, and it might disturb the proper arrangement of the cargo. The captain might be obliged to take it out where he best could, and thus the vessel might be rendered unsafe. One of the reasons why vessels at present were so overloaded was, that at Manchester it was customary, in order to economize freight, to press the goods to such an extent that they really ought to be estimated as dead weight. No account had been taken of this matter as connected with steamers in the paper. When a steamer started, particularly if she carried the whole of her coals, for a long voyage, she starts with a certain load drag arbitrarily fixed and insisted upon by Lloyd's surveyors. She might be a vessel to burn upwards of £50 per day; thus each day's consumption would lighten her to a considerable extent. Was this variation not to be taken into account, and an arbitrary rule to be fixed for all vessels, whether steamers or sailing vessels? Other points must be considered, such as the time she had existed, and what material she was formed of. If it was an iron ship, every year a certain amount of oxidated matter would be shelled off, and imperceptibly her plates would become thinner and thinner; so her intrinsic strength to discharge her duty became less and less. Was there an iron vessel which was registered at Lloyd's, of a certain class, for twenty years, after nineteen years of sloughing off her strength, to be loaded in the same way and to the same extent as when she was first registered? Was a vessel built by Messrs. Wigram or Mr. Samuda to be put in the same category with others pitchforked together by some little ship-builder? The best guarantee, after all, on which the public could rely, was the character of the owners, and builders, and insurers of a ship.

Mr. J. Dudgeon said some years ago he built a steamer for trading in the North Sea, but subsequently found she was too shallow; that if a heavy cargo was put in her the upper deck would be too near the level of the sea. He therefore heightened her 7 ft. 6 in. After he had done this he still found she was not deep enough, and he put a full poop into her upper deck, and a year or two afterwards a new forecastle, and she was now one of the finest ships that ever went to sea. With the materials at present at command, vessels might be made as high out of the water as any one wished, so that it would be absolutely impossible for water to come on board. No iron ship should be built in any other way than with the bottom sufficiently strong to carry the whole of the superstructure, while the superstructure was in the nature of a house with a roof to it. The moment this point was arrived at, the question of vessels foundering at sea would be forever put at rest. On the 29th of December, four years ago, five ships left the same port, one of them being the vessel he had altered in the way he had described, and that was the only one of the lot ever again heard of. The reason that one escaped was because she was built 7 ft. higher out of the water, and in the violent gale in which the others perished, instead of lodging on top to the weight of hundreds of tons, passed off her decks. The other vessels were laden with iron above the water where it was not required, instead of at the bottom. Yet this was the only vessel out of the five that could not be classed at Lloyd's. He believed in a few years the absurd regulations now enforced by the various societies would all be done away with. No force of wave would penetrate a plate of iron one-eighth of an inch thick. Until these sensible views were adopted no good would result. Another point requiring attention was the steerage power of our vessels, which, as a rule, was not so good as it ought to be, our method of applying the power of the rudder, especially in single screw steamers, not being quick enough to meet the necessities of the sea.

Mr. C. H. Wigram thought as the proposed variation was so small as not to amount to more than 3 or 4 in. with a depth of hold of 28 ft., it would only be complicating matters to depart from the present understood rule. The proposed line would be useless as applied to steamers which rapidly varied their draught of water, while it was an admitted principle by all surveyors that steamers might be loaded deeper than sailing vessels. The way the cargo was stored was really of much more importance than the free board. Some years ago a ship laden with an enormous quantity of railway iron stored in bulk and carrying emigrants, got into very bad weather and was compelled to put into

Cork, her topmasts having been carried away. Instead of discharging any of the cargo the captain altered the position of the iron, brought it up from hold, and put it under the berths between decks. This so steadied the ship that she made a very quick and safe passage to New York. Too little attention was at present paid to the stowage of a vessel. A ship was chartered by a certain broker, his object being to get as much into her as possible, and as a rule his stevedore stored the cargo without any reference to the wishes of those who managed the vessel. An owner who allowed such a practice to prevail in regard to his vessels could not justly complain if he met with misfortune. With regard to what had been said about the depreciation of iron ships, it happened curiously enough that this year the Indus, which was one of the first iron vessels, was cleaned and the inside paint taken off the plates, and although she had been built over 22 years, there was no appreciable diminution in the thickness.

Mr. C. Henwood thought the load-draught was a matter which ought properly to be fixed by naval architects. He did not see much difficulty in settling the load line, but he was quite sure it could be done by taking the total capacity, or the length or breadth of a ship, as the basis. He had never heard any reason, however, why it should not be determined from the displacement only. A margin of 25 per cent. of the total displacement might be given for buoyancy for cargo ships, and 50 per cent. for passenger ships. Free board, as a matter of safety, was not of great importance, although of course lofty decks were more comfortable than low ones. He approved of the suggestion made by the council of the Institution, that certain papers should be supplied to the captain of a ship, giving the profile and 1 or 2 sections of spaces. If the centre of gravity of those spaces in relation to the centre of gravity of the ship were recorded on those sections, the stevedore would have a point to start from in filling up the hold.

Captain De Horsey said it appeared to him that the great merit of Mr. Rundell's system was that it did not lay down any dogmatic rule applicable to all ships. Of course, the load line of ships must vary considerably according to her age and the trade she was engaged in. No rule could be stringently applicable to a passenger vessel and to a collier. The system which had just been proposed would simply fix the spot representing one-quarter of the displacement, leaving it free to have the load line so much above or so much below that spot for each particular ship.

Mr. Samuda, M.P., said, although he did not agree with that part of the report of the committee on this subject which recommended that certain things should be made imperative upon the public, he did not by any means think the question should be shelved, or put on one side, on account of its difficulty. Although an absolute solution might never be arrived at, a great deal more might be learned upon the subject by future investigations, so as to guide and direct each individual who might be responsible for carrying out any of the plans recommended. He thought good might be effected if constructors of vessels were compelled to take the responsibility of pointing out with every ship leaving their yards the maximum point at which they would recommend it to be loaded, without making it absolutely obligatory upon the persons who accepted the vessels to follow those recommendations. No doubt great difficulties would have to be encountered in attempting to carry out such a plan. It would involve an elevation in the position of those who would be responsible for giving their recommendations to their clients, which their clients were not at the present moment disposed to recognize. The imposition of an imperative law, which should allow no variation in any way, would be very likely to result in doing exactly the reverse of what they most desired, and would lower the amount of information, and prevent the useful application of the knowledge of naval architecture. Their object should be to acquire and disseminate a much more general information as to the course to be followed by ship-owners, and not at such an early stage to restrict by legislative enactments, or to draw a hard and fast line for the guidance of all.

Mr. Scott Russell said if a customer required an unsinkable ship any good builder could build one ; but if this plan were generally adopted what would become of insurance brokers and other persons of a similar occupation ? He had such a faith

in iron and such a contempt for water that he felt it was quite possible to build vessels that nothing could sink. When a ship is delivered by the builders part of the papers should consist of plans and information for the captain as to the stowage, the centre of gravity, the stability, and the surplus and margin in a ship. It might be required as a portion of the preliminary examination of the captain before getting his certificate, that he should be able to intelligently use those plans.

Mr. W. N. Fenning said it was a lamentable fact that losses of vessels had been very much more frequent during the last three or four years than during the previous fifteen or twenty years. Many of those vessels, too, were what ought to have been fine vessels in which the public could place reliance. He was perfectly convinced that overloading was the cause of an immense proportion of these losses, and until this subject was dealt with in a straightforward manner, the evil would go on increasing. There were ship-owners and ship-builders against whose ships not a word could be said; in fact the vessels of one firm could be insured in Australia 20 per cent. less premium than any other vessels afloat. An owner who inspired such confidence in the public and the underwriters could not suffer by any proper investigation of this subject; he would rather benefit by any law against overloading, because the premiums on all vessels would be lowered. The loss of life by the present want of definite rules was also very terrible. The objection to a fixed rule based on the different buoyancy of fresh and salt water might be met by making an allowance for the difference. Steamers should not be overloaded on the chance of meeting with fair weather until a quantity of coal had been consumed to lighten them to a proper load-draught. If any committee were appointed to inquire into this subject, practical men, members of the different insurance companies, members of Lloyd's, should form part of that committee.

Mr. Rundell, alluding to an expression of opinion which had fallen from the chairman yesterday, said Mr. Inman had upwards of £50,000 interest in the City of Boston uninsured, while he had spent at least £100,000 more in searching for the missing vessel. Replying to the objections made to his proposed system he said that he had regarded the smallness of the difference between the scale of three-tenths displacement, and the scale for Lloyd's, as one of the merits of the proposal. It appeared to him a most extraordinary remark that it would be easy to fix the proper draught for a vessel quite independently of the free side. If the ship were a parallelopiped, then the ratio of the depth of the box would be a very fair indication of the proportion that should be above water, and if it were proposed to have $\frac{1}{4}$ above water, of course $\frac{1}{4}$ of the lineal depth would be the exact amount, and he could not see how $\frac{1}{4}$ of a vessel could be kept above water irrespective of the depth of the side. Although there might be conditions requiring that the length be considered, depth appeared to be the first element taken into account. The application of his system to steamers had not escaped his notice, but the shortness of the time allotted to a paper prevented his discussing that point. The distribution of the weight of cargoes did not affect the draught.

The chairman explained that he had not intended to say anything offensive or injurious to the Messrs. Inman. In his allusion to the City of Boston, he merely expressed his opinion that the agent in Halifax, who had contradicted the report that the vessel was overladen, was the person who had the strongest interest in maintaining such a view of the case. Returning to the more immediate subject of discussion, he said it would not do to rely always on the character of the owner, the builder, and the captain, as suggested by Mr. Laport, for those persons frequently differed in their views. Captains were frequently prevailed upon against their better judgment to overload their vessels, but if they would all take a firm stand, and act according to their own knowledge of the capabilities of their ships, the number and frequency of casualties by sea would be very considerably diminished. A public man, when he took up a great subject, had no business to look to the right or to the left; he should regard only the safety of the public, and he did not hesitate to say that ship-owners and ship-builders were not free from the infirmities of human nature. Great exertions must constantly be directed to the restraint and tendency in human nature to self-interest, and for the safety of the pub-

lic, that restraint was as beneficially exercised when imposed upon owners and builders of ships, as when imposed upon any other class of society. Those who set an example to the rest of the profession of attending to the proper construction and sea-going qualities of their vessels, reaped their reward, in the fact that they could insure their ships upon more favorable terms than other persons. It would not be right to disregard the loss of property, the frightful loss of life, and the loss of national character resulting from such an astounding catalogue of casualties as that which they had heard during the past few months. He perfectly coincided with Mr. Fenning, that many of these had occurred from the fact that ship-owners had yielded to the temptation to load their ships deeper than was safe. The ship was frequently loaded to the extent the ship-owner thought she ought to be, looking to the whole voyage she is to make, and then, in addition to that the coal is added. That such was the case was shown by a number of instances in which the casuality had occurred within a very few hours after leaving the port.

OBITUARY.

Died, on the 27th of April, at Belmont, Mass., by his own hand, ZERAH COLBURN. The funeral took place in Lowell, Mass., on May 4th.

Besides his wife and daughter, and other relatives, there were in attendance such members of the engineering profession as were aware of his decease, and could accommodate their engagements to the short notice given. Among them were Mr. J. B. Francis, Mr. John Souther, Mr. Geo. Souther, Mr. John A. Haven, Mr. John C. Hoadley, Mr. A. L. Holley, Mr. John B. Winslow, Mr. L. B. Tyng, Mr. E. H. Barton, and Mr. Wm. Burke. Hon. Wm. J. McAlpine and others attempted to be present, but were prevented by the shortness of the notice.

The following account of his brief but brilliant career is from the pen of his former associate, Mr. A. L. Holley, contributed to the "New York Times":—

The name of Zerah Colburn is known to the engineers of all countries where professional literature exists, and his writings are perhaps more various in scope, and more vigorous in practical treatment, than those of any other member of his profession. In his death engineering sustains an irreparable loss.

Mr. Colburn was born in Saratoga, N. Y., in 1832, and was named after his uncle, the celebrated mathematician. His father died soon after, and his mother, very poor and infirm, removed to New Hampshire, where, during his boyhood, young Colburn earned his living on a farm. His early means and opportunities for acquiring an education were limited to a few months' attendance at a district school, a short clerkship in a factory, and such books as he could find in a remote country village. But his industry and his wonderful memory more than made up to him then, and throughout his life, his want of early advantages. From an odd volume of the old "Penny Magazine" he gained a knowledge of the world and an inspiration to see and figure in it, which all educational appliances fail to give the average boy of the period. At the earliest possible moment, young Colburn left the wilds of New Hampshire and struck out for civilization, and he kept moving until he finally settled down in its midst—in London. His first sight of a city, and, what was a greater thing to him, a locomotive, was at Concord. The strong but hitherto undeveloped mechanical talent in him at that sight asserted its proper place, and the locomotive was ever after his chief study, and the subject of his best conclusions and ablest writings.

He soon after, as he found means for support, removed to Boston. His first literary attempt was in verse for the "Carpet Bag." His professional career commenced on the Concord Railroad,* under the late Charles Minot, then its manager, who was attracted by the brightness and practical ideas of this singular youth. In a few months Colburn had mastered the anatomy and physiology ot the locomotive engine, tabulated the dimensions and proportions of those under his observation, and published a small, but excellent and still useful, treatise on the subject. He then got a subordinate position, and soon rose to the superintendence of the locomotive works of Mr Souther, in Boston. Here he tabulated and committed to memory (an easy task for him) the dimensions of all parts of the then standard locomotive, and the cost of all the materials and labor employed in its construction. With the exception of a few months at the Tredegar Works, at Richmond, where, in connection with Mr. Souther, he started the manufacture of locomotives, Mr. Colburn then made New York his head-quarters until 1858. His more important professional work at this time was his superintendence for a year or more, of the New Jersey Locomotive Works at Patterson, during which engagement he made some improvements, still standard, in the machinery of freight engines.

Although eminently fitted for the management of practical construction, Mr. Colburn early found that the literature of engineering was his true calling. He therefore joined the "Railroad Journal" of this city, in which, professional readers, soon recognizing the hand of a master, began to look for a new era in technical journalism. And they were not disappointed. In 1854, Mr. Colburn started, in New York, the "Railroad Advocate," a weekly, devoted especially to the machinery of railroads, and addressed chiefly to the master mechanics, and the more intelligent operatives. The next year he enlarged the "Advocate," which soon reached a large circulation and great popularity, not only among railway mechanics, but among the profession at large. It is worthy of mention, as illustrating Mr. Colburn's extraordinary power of memory, that he kept no books for many months, but simply remembered when every subscription and advertisement fell due, and made no mistakes.

* Mr. Colburn strictly commenced his professional career at the age of 15, at the Lowell Machine Shop.

In the summer of 1855 Mr. Colburn thought he saw, in his large and favorable acquaintance with railroad men, the way to a fortune in the business of railroad supplies. He therefore sold the "Advocate" to Mr. A. L. Holley, then draftsman of the New York Locomotive Works, bought land warrants with the money, journeyed to Iowa and located his lands, and then returned to New York—but with another scheme. The frontier life had temporarily charmed him, and he got together an engine and machinery to set up a steam sawmill in the far West. But before his plans were completed, literature and civilization had resumed the mastery, and he fell to writing for the "Advocate," because he could not help writing, and to arranging his supply business. The first thing—and the last—that he undertook in this direction was Ames's tiers, and with his knowledge, industry, shrewdness, and his advantages with the professional press, he kept the hammers at Falls Village busy day and night building up an immense business, which, unfortunately, the character of the tiers did not maintain.

But Colburn was not made for a merchant. He pined for larger professional observation and knowledge, and for a wider field. As suddenly as he went into trade he left it, and sailed for Europe. During a three months' stay or rather rush among the machine and iron works of England and France, whereof the story is recorded in the "Advocate," and is of permanent value, he had become again and finally wedded to literature. Returning to New York, he connected himself again with the "Advocate," which was then enlarged and entitled the "American Engineer."

In the autumn of 1857, Messrs. Colburn and Holley were commissioned by several leading railroad presidents to visit Europe to report on the railway system and machinery abroad, and in view of the financial troubles of 1857, they were advised to stop, at least temporarily, the publication of their paper.

Permanent-way and coal-burning locomotives were found to be the most important subjects of the period, and in 1858 their report on these subjects, largely illustrated by engravings, was published and generally circulated among American railway managers.

Mr. Colburn's thorough and, to American readers, entirely new and startling analysis of the cost and economy of British railways, was the foundation of many of the reforms that have since, although slowly, become standard here, especially in the matter of improved road-bed and superstructure. The success of this book was such that its authors determined to continue their researches, and in the fall of 1858, Mr. Colburn again visited London. Here he commenced writing for the "Engineer," then the leading professional journal, and soon became its editor. Under his vigorous management it largely increased in circulation and influence.

Mr. Colburn at this time wrote a supplement on the American Practice for a new edition of Mr. D. K. Clark's work on the "Locomotive Engine." After several years' hard work in London, Mr. Colburn resolved to start another engineering paper in America. He came out in the Great Eastern, on her first passage in 1860, and soon selected Philadelphia, the principal seat of mechanical engineering in this country, as the birthplace of his own "Engineer." It was an excellent paper, and the few numbers published will have permanent value; but the time was not ripe, in America, for a publication of this kind, and Colburn, although he had learned to labor, had never learned to wait. In a moment of despondency he dropped his new enterprise, sailed for England, and again became the editor of the London "Engineer." At this time he familiarized himself with the French language and professional literature. He also wrote several pamphlets on boiler explosions, heat, etc., the originality of which attracted great attention, and he commenced his great work on the locomotive engine.

In 1866, Mr. Colburn started in London the publication of "Engineering," which is in all countries accounted the ablest and best serial publication on that subject, and he dissolved his connection with it only a few weeks before his death.

During his residence in London, Mr. Colburn was employed as consulting engineer on many important constructions, and prepared many valuable papers in addition to his editorial labors. The more noted of these were his papers before the Institution of Civil Engineers (of which he was a member) on "Iron Bridges" and on "American Locomotives and Rolling Stock," both of which received medals.

Mr. Colburn wrote vigorously, originally, and with understanding on all the leading subjects embraced under the head of engineering. On the locomotive, the steam-engine and boiler at large, steam navigation, bridges, railway works, and mechanical engineering in general, he was a first-rate authority.

The saddest part of Mr. Colburn's story remains to be told. Overwork was at least a powerful agency in his early fall, and this, together with his natural impulsiveness and his habitual irregularity in relaxation, as well as in work, drove him within a few months into partial insanity. He came to this country a fortnight since, avoided all his old friends, strayed away to a country town in Massachusetts, and there died by his own hand.

Zerah Colburn was a man whom the profession could ill afford to lose. His thoroughly practical education in the work-shop, his extended observation of engineering works, his intimate acquaintance with professional literature, his remarkable quickness of comprehension, his more remarkable memory, and his mechanical talent and inborn engineering ideas, combined to give him a distinction that no engineer in the world will deny him—the best general writer in his profession.

IRON AND STEEL NOTES.

Railroad Iron.—"If iron has done so much for us as a nation, and must continue to do for us, at the rate of $600,000,000, in 1900 A. D., have we done our duty to it? Certainly not; for we are making our iron much inferior to that made before this great development, and make it from the best ore in the world. We are growing poorer yearly, even if the quality of our iron remain the same, as we exact greater burdens from it than it can bear, caused by the development of the country over a larger area, which demands higher rates of speed and heavier and longer trains on all our railroads.

We now know that we have laid in the 52,500 miles of railroad 4,725,000 tons, which every ten years must be re-rolled, based on English railroads

(but when based on some of the best railroads in the United States, every four years, based on five years' experience), which (472,500 tons annually) at $75 per ton is $35,000,000, and that this ten per cent. is worn and

By oxidation lost	$3,500,000
And a further cost in car wheels of	1,250,000
And will lose, to re-roll, some $25 per ton	11,812,125
Annual loss to the railroads	$16,562,125

This loss in car wheels is based on their lasting 5 years instead of 2-31, as they do on New York roads, viz., passenger, 1-58; freight, 3-04; and they carry a weight per wheel: passenger, 3¼ tons; freight 1-47 tons, and allow one half for old wheels. In 1900 A. D., the annual loss will be threefold, $16,562,125—based on population—and will double that, based on production of other articles of iron, making a total loss of wear of iron to the nation of between $100,000,000 and $200,000,000 annually. And this loss is made when we own the best ore in the world, caused by several reasons, chiefly by the purchasers demanding a cheap iron, not knowing the value of iron, excepting as based on price, and the competition of the manufacturers againts each other.—*Commercial Bulletin.*

IRON AND STEEL.—The following statement exhibits the quantities of the various kinds of iron and steel exported from Great Britain to the United States, during the two months ended February 28th, of the years 1869 and 1870, in tons of 2,000 lbs.

	1869.	1870.
Iron, pig and puddled	13,814	19,746
" bar, angle, bold, and rod	9,480	7,125
" railroad of all sorts	47,443	64,475
" castings	22	109
" hoops, sheets, and boiler plates	6,374	5,023
" wrought, of all sorts	1,830	1,745
Total	78,963	98,223
Steel, unwrought	2,677	1,680

AMERICAN RAILROAD IRON.—The progress during the last sixteen years, in the production of American railroad iron, is indicated in the following table:

Year.	Tons.	Year.	Tons.
1854	108,000	1862	213,000
1855	138,000	1863	275,000
1856	180,000	1864	335,000
1857	161,000	1865	356,000
1858	163,000	1866	430,000
1859	195,000	1867	462,000
1860	205,000	1868	506,000
1861	189,000	1869	580,000

The production would thus appear to have increased last year to the extent of about 74,000 tons, while the increase in the foreign supplies did not exceed 35,000 tons. These totals are, to some extent, of an approximate character, but still they may be accepted as substantially correct. They show that the Americans are themselves making great exertions to keep pace with the American demand for railway iron; and if we compare the total American production of 1859 with that effected last year, we shall see that enormous strides have indeed been made. Nevertheless, the area of the United States is so enormous, and the field opened out for American railway enterprise is so vast—27,505 miles of line being either projected or in progress at the commencement of this year—that it seems difficult to suppose that the Americans will find it practicable for a considerably further period to dispense with European supplies of railway iron. The question is one of much interest to the English iron trade, but still it is not of overwhelming importance. Thus, while the exports of railway iron from Great Britain in the first eleven months of last year showed an increase, as compared with the corresponding period of 1868, of 300,325 tons, 29,519 tons only arose under the head of exports to the United States.—*The Colliery Guardian.*

RAILWAY NOTES.

NARROW GAUGE RAILWAY.—We gladly insert at a late moment for the present issue the following brief extract from a letter giving some account of successful working of a narrow-gauge railway at the Thomas Iron Works at Hokendauqua, Pa. The line was built to take away the cinders from the blast furnaces:

"The road is 2 ft. 6 in. gauge, and is the same as when we used horse-power. The engines were built by Messrs. M. Baud & Co., at the Baldwin Locomotive Works, in Philadelphia. The steam-cylinders are 9 in. diameter and 12 in. stroke; driving wheels 30 in. diameter with steel tiers 2 in. thick. In order to economize in room, we ascend very rapidly to the tip or dump, and a portion of the road has a gradient of 4 ft. in 100 ft., or 211 ft. per mile. Our cinder cars are four-wheeled, weighing when loaded 3 tons 5 cwt. gross; wheels only 16 in. diameter. The engines weigh, when ready for work with tank full of water, 8 tons. 4 cwt. gross. One of them will haul with ease up this gradient of 211 ft. per mile, 8 of the cinder cars, making an aggregate of 26 tons, and that with a boiler pressure of only 120 to 125 lbs. per square inch.

AMERICAN RAILWAYS.—It appears that the addition to the railway system of the United States during the past year was 6,588 miles, a total nearly twice as large as in any previous year. The first railway in America was commenced with 3 miles at Quincy, Massachusetts, in 1827, and the total length is now 48,860 miles, while there are 27,507 miles projected and in progress. The State with the greatest mileage is Illinois, which figures for 7,186 miles, and is followed by Pennsylvania with 6,878, Indiana with 5,331, New York with 4,735 and Ohio with 4,613. California has already 2,307 miles, and is far above some of the older States, such as Louisiana and Mississippi. The State with the least mileage is, of course, the small one of Rhode Island, which figures only for 131 miles. This account of length of roads does not include the second tracks with which most of the leading lines are supplied, nor the sidings and turn-outs. These may be estimated at 25 per cent. of the length of road, and are being added to yearly. Adding these supplementary tracks to the tabulated mileage, the total length of equivalent single track in use is about 60,000 miles, and adding to this the equivalent for the city passenger tracks, to nearly

65,000 miles. As regards works in hand it is stated that the new year opened with nearly 300 railroads in process of construction between Maine and California. These, it is estimated, when finished, will represent an aggregate of about 15,000 miles, and great efforts will be made to complete them all within the twelvemonth. Assuming the cost of building and equipment at $40,000 per mile, the expenditure will be six hundred millions of dollars for the year 1870. "These figures," it is remarked, "are certainly startling, and may create in the minds of many a fear that the business may be overdone. In years past it was the custom to civilize and populate a section, and afterwards build railroads. But we see this principle entirely reversed. We now build railways and let the country grow up to them.—*Engineering.*

THE BELGIAN STATE RAILWAYS AND TELEGRAPHS.—A paper on the passenger traffic of the State railways in Belgium, with remarks on the telegraphic system, by M. Corr-Vander Maeren, was read and discussed at the last meeting of the Social Science Association. From the statistics quoted in this paper, it appears that the total of the lines in working at the beginning of 1869, in Belgium, was in length 2,730 kilometres, or 546 leagues (about 1,640 English miles), divided as follows:

	Kilometres.
Worked by the State	862
Worked by companies	1,868
Together	2,730

The amount of the capital which the Government had expended for the construction of railways up to January 1, 1868, was together 262½ millions of francs (about 10½ millions of English pounds sterling).

The cost of construction of the State railways amounts to 409,647 francs (about £16,400 per kilometre (or five-eighths of an English mile), divided as follows:

	Francs.
Railway (the cost of the lines)	236,424
Buildings, stations, etc	67,763
General expenses	8,665
Rolling stock	96,795
Total cost per kilometre	409,647

Or at a cost of £26,200 per English mile.

The general result of the working for the year 1858, is as follows:

	Francs.
Total receipts	38,318,509
Total working expenses	24,826,964
Surplus	13,491,545

Or about £540,000.

These 13½ millions of francs profit upon the workings of 1868 give 5½ per cent. upon the whole capital expended upon the railways (say upon 262½ millions of francs).

These figures show that the railways, which have done so much for the country, both in a political and economic point of view, have not only been self-sustaining, but that their general pecuniary result is a profit since their origin of nearly 57,000,000 francs, about £2,280,000, including interest on loans, sinking-fund, and all incidental expenses.

The lowest rates of tariff have been found to be the most productive. The differential fares introduced by the decree of the 20th March, 1866, and now operative, instead of the *fixed* rates of 8, 6, and 4 centimes per kilometre, substituted upon the bases of those rates a system of reduction, decreasing the rates with increased distances. The fares, however, are not so low as they once were, neither are they so profitable. The telegraph in Belgium is, like the post-office and the principal lines of railway, worked by the Government under the direction of the Minister of Public Works. The tariff established by the State at the onset was calculated, by dividing the country into three radii, zones, or different distances, fixing the rates respectively at 2f. 50c., and 5f., and 7f. 50c. for 20 words (2s., 4s., and 6s.).

As the use of the telegraph increased, the tariff was reduced time after time, until the 1st of December, 1865, when the uniform rate of 50 centimes (about 5d.) for the whole of the country was introduced and carried out with great vigor and success. Previously to the 1st of December, 1865, the rate for simple telegrams of 20 words was 1 franc. This was for telegrams of the interior of Belgium.

The telegraph in Belgium has long since completely paid off the entire expenses of its first establishment. Beyond that it shows, on the 1st January, 1869, in the general account, a net profit of about 700,000 francs (£28,000).—*The Builder.*

PULLMAN'S LAST.—The Pullman Palace Car Company is not entirely absorbed by the occupation of new lines. Having absorbed the Central Transportation Company and thus extended its attractions to travellers to a few thousand miles of road, and also the Southern Transportation Company, which has run its cars on 1,500 miles of road in the South and South-east, it introduces a novelty which is likely to make travelling by rail for pleasure more popular and much more desirable than it has ever been before. This is done by means of a car called a "Portable Hotel," which is fitted up in the most elegant manner with state-rooms, parlor, and kitchen, so that a small party—about twenty—may live in it as in a hotel, having in one car just about the accommodations travellers now can get only with two, a drawing-room and sleeping car and a hotel car. But the novelty is rather in the use of the cars than in their construction. It is proposed to let them to parties who will pay for them by the day and travel in them where they please, and stop as often and as long as they please, wherever they please, on any road where Pullman cars run—that is, on most of the great through routes of the North and East. The rent of a car is about $85 a day, and that includes its transportation on passenger and express trains, and the regular complement of servants, including steward, cook, and waiters. The only other expenses are those for catering. This could be done as well as at first-class hotels for $2 a day. Thus a party of 20 could travel at an expense of $6 a day, carrying their hotel with them, living and lodging in the car during their halts as well as while moving. In this way the civilized world may be seen without trouble at comparatively small expense. We anticipate for this latest and most attractive of Pullman's inventions a wonderful popularity. The first trial is made by Mr. Pullman and a party of his friends, who started last Thursday on a tour which is to extend to New Orleans, New York, and back to Chicago.—*Western Railway Gazette.*

THE NEW TURKISH RAILWAY undertaking is to be called the Societe Imperiale des Chemins de Fer de la Turquie d'Europe, and it will issue 750,000 obligations, for which subscriptions will be opened on the 15th inst. at Constantinople, Alexandria, Bucharest, Vienna, Berlin, Amsterdam, Hamburg, Frankfort, Trieste, Lemberg, Prague, Leipsic, Dresden, Munich, Geneva, Berne, Zurich, Milan, Florence, and Naples. These obligations are each for 400f.; bearing interest at the rate of 3 per cent. per annum, with the advantage of lottery drawings with large prizes six times a year, including three of 600,000f. and three of 300,000f. each, besides many smaller ones. The price is fixed at 180f., and the lottery redemptions will be at par (400f.). A public issue cannot be made either in Paris or London, on account of the lottery, but it is is said that the French Government look upon the operation with much favor on account of the political importance of railway communication in giving stability to Turkey, and this feeling will be shared in England. The works are to be commenced at once from each end—the frontier of the Austro-Hungarian empire on one side, and Constantinople to Adrianople on the other.

SWITCHING-ENGINES WITH WATER-TANK FRAMES.—In Great Britain and Germany there have recently been constructed a number of locomotive engines for switching purposes, whose chief peculiarity consists in their having the frames which support the boiler and machinery made of wrought-iron plates, very much on the same principle that wrought-iron box tubular bridges are made. These frames are made water-tight, and are used to carry the water required by the engine. These engines rest entirely on two small driving-wheels placed between the forward part of the fire-box and the hind part of the smoke-box, and this arrangement of the water-tanks is not only compact, but useful in causing an even distribution of weight on the driving-wheels, they being extended well forward, thus balancing the weight of the fire-box. The frames fit closely to the boiler, but are so arranged as not to interfere with its being lifted out when necessary.

THE NORTH-EASTERN RAILWAY OF SWITZERLAND is certainly more successful than most English lines. According to the latest published returns, it appears that the entire capital raised for the construction of the railway and the purchase of two branch lines amounts to 66,808,000 f. (£2,672,320) for an entire mileage of 164 miles, the greater portion of which—namely, from Aarau to Zurich, and thence to the Lake of Constance—has double rails. Of the capital, two-fifths was raised by ordinary shares, and the remainder by obligations bearing a fixed rate of interest, in part guaranteed by the various cantons and in part by the company itself. In 1868 the gross receipts were £295,269, and the net profits, after paying all expenses, £167,555. In this, however, are included the profits realized by the steamboats of the Lake of Constance, which figures for nearly £9,000. The dividend distributed among the shareholders was at the rate of 8 per cent., somewhat in excess of that of any previous year.

THE addition to the railway system of the United States during the past year was 6,588 miles, a total nearly twice as large as in any previous year.

ORDNANCE AND NAVAL NOTES.

THE iron shipbuilding trade at Hull is in a more active condition than for some years, several steamers of very large tonnage being in course of construction, while others are fitting out in the dock. One of the finest steamers ever built at Hull has just been completed.—viz., the Orlando, built by Messrs. C. and W. Earle for Messrs. Wilson, Sons, & Company. Messrs. Wilson have a contract with the Swedish Government for the conveyance of the Swedish mails, and the Orlando is intended for that service, and for the accommodation of the ever-increasing number of tourists to Sweeden.

The Orlando was put upon her trial trip on Friday, and although she was too light to be in good trim she steamed about 12½ knots an hour. She is 260 ft. long. 34 ft. wide, and is 1,400 tons gross. She is fitted with compound engines 38 in. and 76 in. in diameter, 36 in. stroke, and combining all the latest improvements, surface condensation, expansion valves, and everything to insure economy of fuel and speed. Her engines are of 250-horse power and indicated on trial 850-horse power; pressure, 60lbs.; vacuum, 28lbs.; revolutions, 59. The passenger accommodation on board is as follows: Saloon 50; second cabin 32; steerage, or emigrant accommodation, 800. The saloon is amidships, the second cabin aft, and the accommodation for emigrants on the main and lower decks, both of which are lofty and well ventilated. This excellent provision for passengers will make the Orlando one of the most suitable vessels afloat for the transport of troops should occasion arise for her employment in this service.—*Mechanics' Magazine*.

THE PRUSSIAN ARMY.—The "Revue des Deux Mondes" has an article on the state of the Prussian forces at the present time. According to the writer(who, however, is believed to be *not* the person whose signature is attached to the article), the Prussian army consists of: First, the actual army, numbering on its peace footing 140,000 men, but capable of being increased in a few days to 220,000. Second, the first ban of the Landwehr—cavalry and infantry—composed in time of peace of about 3,000 men, the *personnel* only of the various regiments, but numbering on the first summons to arms upwards of 150,000 men. Third, the second ban of the Landwehr, numbering about 110,000 soldiers. This last class comprises all those who under the old system formed the Landsturm, which included all persons between the ages of 17 and 49 capable of bearing arms who are not included in either of the preceding categories. It appears, moreover, from this article, that while the effective strength of the Prussian army has been rapidly increased, its expenditure has, by the introduction of the short-service system, been considerably diminished. In 1820 the average cost of each Prussian soldier was 211 thalers (£31 13s.); in 1859, 214 thalers (£32 2s.); and in 1869, only 196 thalers (£29 8s.) From these figures it is evident that Prussia is actually making a considerable profit out of the contingents furnished by the various States which make up the North German Confederation; for Article 62 of the Constitution allots to the Generalissimo of the Forces (the King of Prussia) a round sum of 225 thalers (£33 15s.), payable out of the revenues of each State, for every soldier furnished to the

Federal forces, while the number of each contingent is fixed at one per cent. of the population in time of peace. The Federal army, on its peace footing for the ensuing year, will consist of 319,000 men.

THE IRON DUKE, a magnificent specimen of naval architecture, was successfully launched from Pembroke yard. This ship is built wholly of iron, and she is furthermore armor-plated with iron slabs, 8 in. thick, down to the water-line. She is a very fine model, and it is fully anticipated that she will attain the speed estimated—namely, 13½ knots—being propelled by twin-screws, driven by first-class engines of 800-horse power, on the trunk principle. Her armament will consist of fourteen 9 in. guns, twelve tons each, so that taking this into consideration, together with her armor and the immense speed anticipated from her, she will undoubtedly prove a most formidable antagonist. Her accommodation for officers and crew is excellent. The between-decks are about 10 ft., thus insuring, with other appliances, good ventilation.

NAVIGATION.—The experimental brig Novelty, constructed simply as iron tank, to hold molasses in bulk, which arrived in Boston from Matanzas, discharged her cargo of 88,000 gallons, by means of pumps and hose, direct into the reservoir of a refinery, was refilled with Cochituate water, shipped a new crew, got ready for sea, and departed within 27 hours from the time of her arrival. There is no room, says the New York "Tribune," to doubt the immense improvement of this mode of transporting molasses.—*Iron Age.*

THE RUSSIAN FORCES.—The "Invalid," organ of the War Office at St. Petersburg, gives us a sketch of the state of the Czar's forces. This year the active Army consists of 726,000 men, or about 10 per cent. of the population capable of furnishing recruits, in which are not comprised the people of Finland, the Caucasus, Central Asia, parts of Siberia, and the Cossacks. The reserve has been considerably augmented. In 1865 it numbered 190,000 men; in 1866, 333,000; in 1867, 410,000; in 1868, 460,000; in 1869, 511,000; and in a few months' time it will reach 553,000 men, all, says the "Invalid," well drilled! As the strength of the reserve on a war footing should only reach to 430,000 men, the War Minister has a handsome surplus in hand, and appears as proud of it as a Chancellor of the Exchequer who has managed to save a few millions. To this active army and reserve must be added the Cossacks, who furnish in time of war 133 regiments of cavalry, 24 battalions, and 200 guns; in all 300,000 men, which is very respectable as an additional force. The new armament of the Russian Army will be terminated, we are told, about the 1st April next, when Russia will possess 965,000 breech-loaders; 622,000 being on the Krok, 60,000 on the Berdan, and the remainder on the Karl and Baranow systems. The Navy is armed with Baranow rifles. There are manufactories of arms at Zoula, Zjew, Lestroretsk, Tiflis, Warsaw, Kiew, St. Petersburg, etc., and in the capital three factories turn out half a million of metallic cartridges per diem. All the field batteries are furnished with guns on a new system, even those of the Cossack corps. There are more than 1,200 of these pieces, without counting 90 mitrailleuses, whose number is to be considerably augmented. The fortresses possess 1,000 improved guns, all cast in Russia, with the exception of the large pieces from Krupp. Thanks to a wise Administration, says the "Invalid," all these changes have been effected in a most economical manner, and in the matter of discipline there is nothing to complain of. It is well to remember, adds the organ of the War-office, that the law of March, 1869, in admitting sub-officers to the schools of ensigns opens up to them the grade of officer. No wonder that this immense force requires new strategic railways, and a loan to make them.—*Army and Navy Gazette.*

ENGINEERING STRUCTURES.

THE GREAT UNION DEPOT ON FOURTH AVENUE, NEW YORK.—The contract for this enormous structure has been finally awarded to the Architectural Iron Works at the foot of Fourteenth street, New York. The depot is intended to accommodate the trains of the Harlem, Hudson River, and New York Central Railroads. For the latter a branch road will be built to connect with the Harlem, the trains being switched off in the neighborhood of Spuyten Duyvil. The car-house will have accommodations for 12 single trains, while, if it be necessary, double or even treble that number can be accommodated.

Photographs of the plans and drawings were sent to Europe for bids, but it was found that American foundrymen could more than compete with any bids received abroad.

The foundation of this immense structure, to be the largest of the kind on this continent, is well under way—in fact, nearly completed. The contract calls for the completion of the entire structure within 8 months from its date. If not completed within the time specified, the contractor is to forfeit and have deducted from the contract price $500 a day for every day over; and if completed within the time specified, the contractor is to receive, in addition to the contract price, the sum of $200 for each day the work is so completed and accepted by the engineer.

The weight of iron to be used will be over 8,000,000 lbs. It will require 100,000 square ft. of glass in the roof alone, and 90,000 square ft. of galvanized corrugated iron to cover the roof. The roof over the car-house will extend over an area limited south and west by the office buildings, east by the Fourth avenue, and north by a line 30 ft. 6 in. south of Forty-fifth street. The entire length of the roof will be 652 ft., and it will be 199 ft. 2 in. in width between the walls, and supported by 32 arched trusses placed 20 ft. 4 in. apart. These great arches will be set upon the foundation, whose upper face is 2 ft. below the surface of the ground, rising to an elevation of 94 ft. from the springing line to the extrados of the arch.

The car-house is to be lighted through 3 skylights extending over the entire length of the roof—1 on the centre, double pitched, and 2 single ones on each side of the centre. There will be 7 courses of ventilators running the entire length of the roof, faced up with stationary sheet-iron slats. On the south end, the segmental portion of the arch above the brick wall will be faced with cast-iron trimmings and plate glass.

The north end will be closed with a beautiful cast-iron front highly ornamented. The east side,

along the Fourth avenue, will be finished with cast iron pilasters acting as casings set in front of each truss. These pilasters are to have bases and caps, supporting a main cornice along the front, and crowned by a cast-iron balustrade; a line of balconies will run along the west side and across the south end, connecting with the offices in the second story. The trusses are placed in heavy cast-iron shoes, 64 in number. To permit free expansion and contraction of the trusses, without interference with the side walls crossed by them, there will be placed cast-iron boxes or casings perforated by a series of cores, and fitted together by means of bars and angles in such a manner as to insulate entirely the mason work from the trusses.

The rafters will consist of 5-in. deck beams, secured to the top chord by double angle iron studs, 3½ by 3½ in., and stiffened by diagonal braces of same size; riveted together and fastened on the chord by means of bent lap plates ½ in. thick, and riveted to the former.

The doors and windows will have cast-iron trimmings, all ornamented, the windows to be glazed with rough ¼ in. glass. The whole of the north front will be of cast-iron, the width to be 203 ft. 10 in., and raised 112 ft. 6 in. extreme height. The windows and doors of the first story will have rolling shutters.

The ends of the structure will be occupied for offices on the first floor, while the ground floor will be set apart for ticket offices, passengers' rooms, baggage lockers, restaurants, news-stands, etc.

Pennsylvania iron of the best welded quality will be used for plates, flat or square bars. Round bars and rods for braces to be of Ulster iron; rivets and bolts of charcoal iron. Sheet iron, best welded and refined Pennsylvania. Cast iron mixed in the following proportions, viz.: American pig No. 1, and Scotch pig No. 1, 5 per cent. of each for shoes, casings, lintels, box, angle, studs, and braces. American pig No. 1, 10 per cent., and Scotch pig No. 1, 15 per cent., for columns and pilasters. American pig No. 1, 15 per cent., and Scotch pig No. 1, 20 per cent., for hanging cornices, friezes, and flat panellings. American pig No. 1, 30 per cent., and Scotch pig No. 1, 30 per cent., for small mouldings and ornamented work. All rolled and welded iron to be subject to a strain of 30,000 lbs. per sectional inch.—*Scientific American.*

Good Tunnelling.—A great underground work is the Ernst August Gallery—one of five belonging to a metal mine in the Hartz. "The mouth of it is at Gittelda, in Brunswick. It is 10 ft. high, 6½ ft. wide, and has a fall three-fifths of an inch in a yard. Like a railway tunnel (but it is twice the length of the longest), it was begun simultaneously at various different points, and finished in 13 years. The gallery is 6¼ miles in direct length; but if its lateral branches are taken into account, and a subterranean gallery, navigable for boats, which opens into it, the Ernst August Galleries are said to be not less than 15 miles long. All the junctions of the different sections fit accurately into each other, the precision of the results having been partly insured by the aid of a magnet, weighing 200 lbs., which influenced the compass through the solid rock 65 feet deep, and which was kept in one of the working-places, while the compass was held in the other.—*The Builder.*

New Suspension Bridge in Texas.—The new suspension bridge at Waco, Texas, is a work of great importance to the South-west. It is on the main line of travel from Memphis and the Red River, through Central Texas, to the Rio Grande.

It is a suspension bridge of 475 ft. span, 18 ft. wide. The towers are of brick; the foundations are upon rock on on side and quicksand upon the other.

The iron work was constructed in New York, and the entire amount of wood work was hauled 80 miles by ox teams.

A pile-driving machine was improvised by the engineer, the hammer being of live oak, banded with iron from old wagon axles.

The pumping inside of the coffer-dams was done by a force of negroes, using log pumps.

Waco is about 300 miles from Galveston. The engineer is Mr. Thomas M. Griffith.

The Channel Bridge.—Sir: I am tempted to trespass on your valuable space in order to correct some misapprehension on this subject, by the spirit of impartiality which has been shown by your journal on the subject of the various plans proposed for crossing the Channel. You have, I believe, expressed an opinion that a bridge, if it could be made, would be the best plan, as it would be the most natural, and the safest and most agreeable for public use.

It is unfortunate that the exceeding interest which attaches to the subject generally, and the important character of the steps which have been taken towards ascertaining the practicability of M. Boutet's bridge, which Captain Tyler, in his report to the Government on the subject, stated was the one which had made most progress, have led the papers to discuss it before the author is prepared to make it public. It has, however, been recently stated that his proposal is for a bridge on 190 piers, costing 30 millions, instead of which it is to have 29 piers only, and to cost but 8 millions. It has also been said that there are no English subscribers to it, and that French engineers deem it unworthy of notice. I am proud to say I am an English subscriber; and I was present at the meeting held in Paris on the completion of the 66 ft. model, at which English subscribers attended, and proxies were produced from others who could not attend. French engineers were there and addressed the meeting, and I met afterwards engineers of eminence in Paris who spoke favorably of it. Notably General Fair, the director of Ecole Polytechnic at Paris, and the engineer of the Montmorency Railway; and it was stated by the President at the meeting, Comte Cardaillac, who is at the head of one of the departments of the French Government, that a commission of French Engineers, whom the Emperor had met to examine the plan for his private satisfaction, had reported favorably upon it, and that the Emperor was in consequence prepared to order a bridge of 100 metres to be built on M. Boutet's system, which is now in progress, and bids fair to rival its predecessors in interest and importance, and be as great a success as every other step in this matter has been. The best proof of this is that those who have subscribed towards the work are satisfied with the progress which has been made, and look forward with confidence to the successful development of the system which is in contemplation.

M. Boutet has been blamed for not having made

his plan more public, but I think he is to be commended for desiring to ascertain first the efficiency and powers of his system. I am, sir, yours, &c.,

LONDON, *March* 22. FAIRPLAY.

—*Mechanic's Magazine.*

THE Russian Government is making a very important experiment. The Exas now flows into the Sea of Aral. It once flowed into the Caspian, its old bed being still visible enough to be a feature in maps. If it could be brought back, the Russians would have an unbroken and impregnable water communication from the Baltic to the heart of Khiva, and, with further improvements to Boekh, would, in fact, be able to ship stores at Cronstadt for Central Asia, and send them without land carriage. The addition to their power would be enormous; and their engineers think it can be secured. An energetic officer, with eighteen hundred men, is already on the south bank of the Caspian; the natives are reported friendly, and the Russian Government has the means, through its penal regiments, of employing forced labor on a great scale.

THE WATER SUPPLY OF SYDNEY.—The commission appointed to inquire into the best means of supplying Sydney and its suburbs with water, have lately submitted their report to Parliament. Their labors have extended over a period of two years. In their report they have given the outlines of a scheme which seemed to them, on the whole, to be superior to all others examined, and they therefore agreed to recommend its adoption—the scheme, namely, of bringing down the waters of the higher affluents of the river Nepean by gravitation. The catchment area is 354 square miles in extent, the rivers that drain the selected district take their rise mostly in swampy flats between 1,200 and 1,600 ft. above the sea; but at the confluence of the Corbeaux with the Nepean, where it is proposed to make the first interception of the waters, the height is 430 ft. In regard to extent of surface, purity of water, freedom from sources of contamination, want of value in the lands for other purposes, and altitude above the sea, the commission consider that there is in this scheme all that can be desired; the great drawback is the distance from Sydney (63 miles measured along the proposed conduit), which, though not important in an engineering point of view, will necessarily be a source of great expense. Instead of constructing dams, it is proposed to construct one large reservoir apart from the river, where they would not be subject to floods. Good sites for reservoirs have been found near Prospect, 21 miles from Sydney. It is proposed to convey the waters to Prospect by means of canals, tunnels, and raised aqueducts. Two methods for bringing the water from Prospect to Sydney have been considered by the commission. First, a high level scheme, by which the water would be impounded at a maximum height of 260 ft., in a large reservoir, with a possible additional height of 20 ft. by means of a small reservoir higher up—the water to be brought down to Sydney (a distance of 21 miles) in pipes. And, second, a low level scheme, by which a larger body of water would be impounded at a maximum height of 195 ft., and be brought to Sydney by 8 miles of open conduit, and 13 miles of pipes. It was estimated that the high level scheme would cost £1,046,846, and the low level, £790,029. After prolonged deliberation the commission agreed to recommend the low service scheme for adoption. In concluding their able report (which was a very lengthy one) the commission point out reasons for believing that costly as the work would be, it might be made productive.—*The Artizan.*

NEW BOOKS.

HAND-BOOK OF THE STEAM ENGINE, containing all the rules required for the right construction and easy management of engines of every class, with the easy arithmetical solution of those rules. Constituting a key to the Catechism of the Steam-Engine. Illustrated by sixty-seven woodcuts and numerous tables and examples. By JOHN BOURNE, C. E. New edition. Philadelphia: J. B. Lippincott & Co. For sale by Van Nostrand.

That this excellent work has reached a third edition is some evidence that its merits are appreciated, and that it supplies a want among rising engineers.

Young mechanics find in it an efficient supplement to the theoretic knowledge obtained at the day or night school.

Practical engineers use it as a good compendium of the rules for engine construction and management.

CYCLOPÆDIC SCIENCE SIMPLIFIED. By J. H. PEPPER, Professor of Chemistry in the Royal Polytechnic Institution. London: Frederick Warne & Co. New York; Scribner, Welford & Co. For sale by Van Nostrand.

This is, without doubt, the most complete compendium of experiments in physical science, in the English language.

The several divisions of the work are given under the heads of: light, heat, electricity, magnetism, pneumatics, acoustics, and chemistry.

There are 540 illustrations, many of which, illustrating lecture-room manipulations, are so skilfully designed as almost to render the descriptive text unnecessary.

A MANUAL OF QUALITATIVE ANALYSIS. By ROBERT GALLOWAY, F. C. S., Professor of Applied Chemistry in the Royal College of Science for Ireland. Fifth Edition. London: John Churchill & Sons. 1870. For sale by Van Nostrand.

This treatise on chemical analysis, through the care of its author to make it accurate and to adapt it to the wants of the earnest student, has long been established as one of the best in our language. It was at one time a distinguishing character of this work, that in it the art of chemical analysis is taught by first giving appropriate exercises, and then helping the student to deduce from these the principles and rules of the art. In other treatises, the student was first carried through a sort of grammar, and then taught the application of this to the execution of the purposes of the art. Now, however, Professor Galloway's *Qualitative Analysis* does not possess this distinctive character, for the simple reason that in most of its fellow-treatises the same principle has been more or less fully adopted, though in none so thoroughly as in it.

In its present edition it forms a much more comprehensive work than in the previous ones. As it now stands, it includes, besides other matter,

a very full descriptive account of the more important and best-known substances, in which their chemical properties are compared and contrasted in a very useful manner. And it seems to us, after an examination of its pages, that no method of learning chemistry would prove so successful as that of working out such a practical course as that laid down in it, and at the same time attending a *few* lectures on the doctrines of the science.

In addition to the account of salts and acids, together with their radicals, to be expected in such a work, descriptions, to be verified by experiment, are given of almost every "organic" substance of interest in medicine, physiology, toxicology, and the arts. The action of heat upon substances as a means of ascertaining their nature is elaborately detailed, the author availing himself of the papers of Bunsen and Merz upon the use of the Bunsen lamp as an instrument of analysis.

In the present edition Professor Galloway has adopted the modern notation and nomenclature, and, what is of more importance in a work on practical chemistry, he has added many tests to those given in the fourth edition. We consider it an omission of the author, and we have observed no other worth notice, not to have given an account of Bunsen's admirable, quick, and thorough filtering apparatus. Probably he thought it adapted for quantitative rather than for qualitative experiments; but, if so, we are hardly prepared to agree with him. Of all things most calculated to dishearten the student of qualitative analysis, the filtration and washing of slimy precipitates rank first, and therefore, to deprive them of their tedious character is to confer a very great boon on the student, and to favor the cultivation of chemistry itself.—*From Scientific Opinion.*

A new System of Ventilation. By Henry A. Gouge. 8vo, 176 pp. New York: D. Van Nostrand, 1870.

It is related of Faraday that he one day tried some experiments on the purity of the Thames water in London, by sinking bits of white paper. The next day he wrote a letter on the subject to the London "Times." This letter had more to do in calling attention to the dangerous sewage system of the city than anything that had appeared from any other source, and eventually led to the expenditure of millions of dollars in the construction of the great Thames embankment, for rectifying the evil. We want a second Faraday to arise in this country, and warn the people of the danger of neglect of ventilation. The author of the book, the title of which we have just given, shows how necessary fresh air is to health, and he gives startling examples of the ill consequences of a neglect of the rules upon this subject. He has a somewhat original way of presenting his claims, but if he can accomplish his object he will be doing a good work. The quotations from some of our most distinguished writers are much to the point, and add to the interest of the book.—*Journal of Applied Chemistry.*

Bibliotheque des Merveilles. Paris: L. Hachette & Co. For sale by Van Nostrand. In reviewing various English translations from French authors, that have of late been introduced among us, we have had occasion to refer to MM. Hachette, of Paris, as being the most useful and elegant of French publishers in the special branch of literature we are now alluding to. Such works as "La vie Souterraine, Les Voyages Aèriens", and others of the same class, are invaluable for the amount of information they contain, and the manner in which it is arranged for the capacity of the general reader. It is certain that accurate and artistic engravings convey more to many minds than a simple description, while no amount of technical language will be satisfactory to the uninitiated reader; a few strokes with the pencil often do better service than much hard labor with the pen, and information thus conveyed being more striking, is retained longer in the memory, than much technical description. In working upon this system, MM. Hachette have spared no pains in making their educational works perfect, and while such volumes as we have mentioned cannot, from their high cost, command a universal sale, a valuable and cheap series under the general title of "Bibliothèque des Merveilles," is in course of issue by the same publishers, which within narrower limits pursues the same object. Such is "Les Chemins de Fer," by M. A. Guillemin, a carefully written handbook, fully illustrated with drawings, which range from a navvy's pick and spade, to locomotives and rolling stock details, the object in view being to bring graphically before the reader, the nature of all necessary works, and the mode of carrying them out. It is not urged that such a work will be found of great service to the engineer, but it forms rather a means by which every one can make themselves acquainted with a subject of which they are generally ignorant.

Of the same nature is "L'Acoustique," a complete elementary text-book on the phenomena of sound, philosophical and historical, written throughout in a pleasant easy style. In addition to these we may add "La Fond de la Mer," "Les Armes et les Armures," by P. Lacomte, "Les Ascensions Célèbres, L'Eau," by M. Tisandier, and "L'Electricété," by M. J. Baillie. Such are a few volumes of the Library of Wonders of MM. Hachette, and we are glad to know that most of them are being reproduced here for the benefit of English readers. For the present we may content ourselver with this brief notice of the series, feeling assured that the publishers have conferred an international benefit in their production.—*Engineering.*

The Elements of Building, Construction, and Architectural Drawing. With one hundred and thirty-three illustrations drawn on wood by the author. By Ellis A. Davidson, Science and Art Lecturer in the City of London Middle Class Schools, etc. London and New York: Cassell, Petter & Galpin. For sale by Van Nostrand.

This handy little volume is the third of a series of excellent technical annuals by the same author, which Messrs. Cassell have lately issued for the use of the student and the artisan. Although the book consists of but 120 small octavo pages, it contains a much greater amount of useful information relating to the subjects of which it treats than many works of far greater pretensions—a result which Mr. Davidson has attained by carefully avoiding all verbosity, and occupying the space at his disposal solely with clearly stated facts. Commencing with a chapter on the drawings required for building purposes, our author next treats of the general principles of building, construction, of foundations, natural and artificial, and of coffer-dams, caissons,

and similar appliances. Then come chapters on masonry and on brickwork, and these are followed by others on drawing for bricklayers; on woodworks; on the construction of roofs and floors; on partitions; on joinery; and on fire-proof construction. The information given on all these matters is excellent, the clearly written text being rendered still more clear by the numerous wood-cuts by which it is interspersed. This little manual is, in fact, the best work of the kind which we have seen, and in heartily recommending it to the classes for whom it was written, we may express a wish to see many other such books from the same pen.—*Engineering.*

THE SCIENCE OF BUILDING. An elementary treatise on the principles of construction, especially adapted to the requirements of architectural students. By E. WYNDHAM TARN, M. A. London: Lockwood & Co. For sale by Van Nostrand.

The separate chapters treat of—

1. Mechanical principles.
2. Retaining walls.
3. Arches and cupolas.
4. Building stones.
5. Timber.
6. Iron.
7. Water in vessels and pipes.

A scientific treatise, presenting topics of an advanced grade of technical art, but involving no higher mathematics than geometry and algebra.

QUALITATIVE CHEMICAL ANALYSIS. By DR. C. REMIGIUS FRESENIUS. Seventh Edition. Edited by ARTHUR VACHER. London: John Churchill & Sons. 1870. For sale by Van Nostrand.

We doubt very much that an English chemist will be found in the present state of things who can write a work on chemical analysis equalling, both in exactness and minuteness of detail and in the originality of its contents, that which can be written by a German. At least in Germany we find chemists who are both able and willing to devote a lifetime to the developing and perfecting processes for the detection and quantitative estimation of substances, and are not very likely to find such men in England. We are led to express this opinion by having before us the new English editions of the two volumes of Fresenius on "Chemical Analysis." The Wiesbaden Professor is a pre-eminent instance of one who has devoted a lifetime to the object we have indicated. He has raised in these works monuments to the vast assistance he has afforded to other chemists in their labors, which will remain long after him, but which can never bring him that renown that an equal application of his abilities and time to other branches of his science would have done.

The treatises on Qualitative and Quantitative Analysis by Fresenius have for a great number of years been familiar to English students and teachers of chemistry in the excellent translations of Mr. Lloyd Bullock. They are now given to us by the hands of Mr. Arthur Vacher, who has not merely reproduced the substance of them, but has freely availed himself of his editorial capacity to make such modifications as he deemed improvements in them.

We cannot epitomize more briefly than the editor has done the differences between the sixth edition of the "Qualitative Analysis" and the seventh:

"Several improvements, necessitated by the progress of discovery, have been introduced by the author; and I have specially striven to meet the wants of English students. The language has been condensed, the notation and nomenclature have been modernized, the arrangement has been simplified. The consideration of rare inorganic bodies and of organic bodies has been deferred to the latter part of the volume, where a section has been devoted to each. The grouping of the metals has been harmonized with the course of analysis. The course of analysis has been simplified in description, and the preliminary examination has been curtailed. Analytical tables have been added at the end, which include the preliminary examination and the detection of metals in soluble mixtures."

The improvement is material in the arrangement for the analysis of mixtures of salts, most of the tiresome references to other pages having been avoided.

The section on the detection of the alkaloids continues to be an extremely valuable part of the work.—*From Scientific Opinion.*

THE SECOND COURSE OF ORTHOGRAPHIC PROJECTION; being a continuation of the new method of teaching the science of mechanical and engineering drawing; with some practical remarks on the teeth of wheels, the projection of shadows, principles of shading, and drawing from machinery. With numerous illustrations. By WILLIAM BINNS, Assoc. Inst. C. E. London: E. & F. N. Spon, Charing-cross. 1869. For sale by Van Nostrand.

After an interval of some years, Mr. Binns has supplemented his Elementary Treatise on Orthographic Projection with a second volume, in which he has compressed the pith of the lectures delivered by him at the late College for Civil Engineers, Putney, and at the Department of Science and Art, Kensington. In this second course of Orthographic Projection, he has propounded the importance of establishing a uniform system for the formation of the teeth of wheels, and having compared the various methods now in use, and slightly altered that which is considered the best among them, he hopes his improvement will be recognized and universally adopted, so that for the future there may be but one form. As matters now stand in this department of mechanical engineering, two wheels of any given pitch obtained from different makers will not work together, because every maker has a formula of his own for the shape of the teeth, which he believes to be the best, but which, as we have remarked, prevents his wheels from working with those obtained from any other firm. After describing the methods pursued by various engineers, including that obtained by the use of the odontograph, he lays down a plan, by the adoption of which the inconveniences attending the present diversity of rules might be done away with. He proposes:

"1. That there shall be a generating circle for every pitch, and that the pitch be stamped or otherwise marked on each 'scriber,' or generating circle.

"2. That the diameter of each generating circle be equal to the radius of the least wheel of the set.

"3. That the number of teeth assigned to the least wheel be fourteen for all sets of wheels for mill gearing."

The proposal of a universal epicycloidal system has been made before now, but from the fact of a

want of sufficiently definite terms it fell to the ground. The diameter of the scriber, for instance, was left to the judgment of each maker. Mr. Binns's more precisely stated proposal is likely to be useful. To those in want of plain instructions on orthographic projection, we commend the work, generally. The author, we perceive, particularly recommends to pattern-makers the section of it we first mentioned.—*The Builder.*

A Manual of the Chemical Examination of the Urine in Disease; with brief directions for the examination of the most common varieties of Urinary Calculi. By Austin Flint, Jr., M.D., Professor in Bellevue Hospital Medical College. 12mo., pp.76. New York: D. Appleton & Co., 1870.

This is a handy book for the use of physicians who may be called upon to make tests of urine. There is a list of all the reagents and apparatus required, and the latest methods both for qualitative and quantitative analysis of urine are concisely stated. The tables will be found convenient, and as they are printed on a separate sheet at the end of the book, they can be cut out and framed for immediate reference. The book is illustrated by good wood-cuts of apparatus, thus greatly adding to its value. We do not know of any work in English so complete and handy as the manual now offered to the profession by Dr. Flint, and the high scientific reputation of the author is a sufficient guarantee of the accuracy of all the directions given.—*Journal of Applied Chemistry.*

Causeries Scientifiques, Decouverts, et Inventions, Progres de la Science et de l'Industrie, etc. Par Henri de Parville. J. Rothschild, Paris. 12mo., with illustrations. For sale by Van Nostrand.

The ninth volume of M. de Parville's annual record of scientific and industrial novelties, always a welcome publication, not only on account of the matter itself, but also of the lucidity of the style, the liberality with which the text is illustrated by practical diagrams, as well as picturesque illustrations, and the clear type.

Amongst the most remarkable articles in the present volume, are those on the Health of Towns and the Utilization of Sewage; Military Art, including a discussion of Captain Moncrieff's invention, with account of a similar system tried in the commencement of the present century; Tromee's Electric Sound for finding Bullets in Wounds; An account of the very remarkable researches of M. Marey, of the College of France, on the Flying Mechanism of Birds and Insects; On the powers of the Picrates and other Explosive Substances; And an account of the Formation of the Suez Canal, with engravings of the machinery employed, and a panoramic view of the isthmus.

Our young readers, who desire to keep up or improve their French, will find M. de Parville's well-written and handy volumes valuable.

Principles and Construction of Machinery: a Practical Treatise for Students, Engineers, and Practical Mechanics. By Francis Campin. C.E. London: Atchley & Co., Great Russell street. For Sale by Van Nostrand.

A past president of the Civil and Mechanical Engineers' Society, as Mr. Campin is, cannot but be a fitting and competent writer on the principles and construction of machinery. Mr. Campin here treats of the laws of the transmission of power, and of the strength and proportions of the various elements of prime movers, mill work, and machinery generally. The work is the substance of a carefully revised digest of the author's oral instructions as a teacher in training pupils. He has aimed at setting forth fully the laws of construction in reference to strength of parts, while stripping the subject of much cumbrous matter with which it has heretofore been loaded. He teaches not only why a given machine produces a certain effect, but also how practically to make it. —*The Builder.*

Traite de Topographie. Par E. Maes. Librairie Militaire. Paris. For sale by Van Nostrand.

This is a well-printed volume, royal octavo, of 330 pages, containing, besides instructions in the methods of "surveying" and "levelling," complete and minute directions for mapping, reducing plans, and finally, photo-lithographing the maps.

A folio volume of thirty plates accompanies the text.

The surveying methods described are designed for military engineers, but afford excellent suggestions for railway engineers while making reconnaissances.

A Manual of Zoology for the Use of Students. By Henry Alleyne Nicholson. Vol. 1., Invetebrate Animals. London: Robert Hardwicke.

This work is well designed for thoroughly scientific instruction. The classifications are completely set forth, and the latest views and discoveries are noted.

The illustrations are abundant, although not elegant.

Volume 2 is not yet at hand.

MISCELLANEOUS.

Sir Joseph Whitworth on Street Tramways and Road-making.—The use of horse tramways is being urgently pressed forward, and a large outlay is contemplated. In Sir Joseph Whitworth's opinion, however, they are not suited to the present times, and mechanical engineers have a right to enter their protest, considering the many obstructions there have been for many years past to the employment of road locomotives. If toll gates were abolished, and each county had an organized staff for making and keeping the roads in good order, using the steam roller, steam sweeping machine, and other necessary appliances, where there is a large traffic, mechanical engineers would then, Sir Joseph has no doubt, soon produce a small light locomotive that would do its work quietly and most effectually; at the same time, pedestrians and those who ride and drive would have the great enjoyment of good and clean roads, instead of the present badly paved and rough macadam roads. The broken stones of the latter are now left for the horses' feet and narrow wheels to consolidate in a way which is quite distressing to see. The consumption of fuel per horse power is now so small, that road locomotives could be employed at far less expense than the over-worked and ill-conditioned horses we now see, while pedestrians and those who keep animals for

pleasure would have good roads, and many gentlemen, no doubt, would have their well-made locomotives. Under any circumstances, good clean roads are the most profitable when everything is taken into account; but unfortunately those who make and repair them generally consider only one side of the question.—*The Building News.*

THE SEWAGE QUESTION—LEEK.—The clean and good-looking little town of Leek promises to become, in vital statistics, a model town to the country. The sewerage works have been in existence nine years. The beneficial results have been great. The annual number of deaths in the decade ending in 1860 was 29 to the 1,000; during the last decade it was 24; and the average ages of the dead have risen from 24.8 to 32.5. Thus the average duration of life has been prolonged by nearly one-third. 492 persons are now alive in Leek, who, had the ratio of deaths in the first decade continued, would now have been dead. Those who died during the last decade lived, in the aggregate, 16,309 years longer than they would had the average age at death during the previous decade been continued. Had no sanitary improvements been made, many would have been widows and orphans whose husbands and parents are now living. There has been a corresponding decrease in sickness, the money savings of which, reckoning each case at five shillings a week for 50,752 weeks, amounts to £12,668. Of the sickness prevented 16,917 weeks are saved to the workers between 15 and 55 years of age, being a saving of £6,343 1s. 6d., even though a man's wages were only 10s., and a woman's 5s. per week. The funeral expenses saved, at £5 each, amounted to £2,460. The direct money saving was £21,491 17s. 6d., not to speak of the unspeakable advantages of every kind from improved health and prolonged life. Thus the drainage of a town not only benefits the owners of property, it benefits the poor above all persons.—*The Builder.*

FOREIGN TELEGRAPHIC NEWS.—Advices from Yokohama, Japan, to the 24th January, state that the new telegraph line between Jeddo and Yokohama has been completed—the first message having been sent over the wires January 7th. The line will be thrown open to mercantile purposes very soon.

After a lapse of some years efforts appear to have been successfully made for re-establishing direct communication between England and the Channel Islands. The Jersey and Guernsey Telegraph Company propose to lay a new cable by a shorter route than the one previously adopted, more advantageous in every respect; and they also propose to use a much stronger and more suitable cable than the one previously laid over the longer route, and which proved an expensive failure. The new cable will be laid from a point near the Start across to Guernsey, and from thence to Jersey. The longest length of the cable required by the company can be laid in one day; and as the greatest depth of water will not exceed 70 fathoms, any repairs that may be required can be quickly made. The cable has been contracted for, to be manufactured and laid within a short period, for the sum of £25,000; and a further agreement has been made with the manufacturers, who will, for the sum of £1,000 per annum, maintain the cable in perfect working order for 5 years.

To avoid the liability to interruption of the land line of 600 miles in length across the Island of Cuba, in completing the connection between the cables of the International Ocean Telegraph Company and the extensions to Jamaica and Panama, the Cuba Submarine Telegraph Company has been organized, with an exclusive concession for 40 years, for laying a Submarine Cable from Santiago de Cuba—the landing place of the Jamaica Cable, at the southeastern extremity of Cuba—to Batabanos; from thence a land line will be erected along the railway across the Island to Havana, a distance of about 30 miles; there it will join the cable to the United States. The length of the cable will be 540 miles, and will be manufactured and submerged by the India Rubber, Gutta Percha and Telegraph Works Company, for the sum of £147,000, and is to be of the same efficient description as that made for the International Ocean Telegraph Company and for the West India Company. The directors state that it is expected that the cable will be laid within the next four months—arrangements having been made with the contractors for its manufacture and simultaneous shipment with the first portion of the West India and Panama Company's cable at the end of March next, so as to connect, without delay, the terminus of that company's line with those of the International Ocean Telegraph Company.—*The Telegrapher.*

ARTIFICIAL ICE-MAKING IN THE SOUTH.—An enterprising citizen of Columbia, S. C., has ordered an ammonia ice-machine from Europe, which is to turn out 1,000 lbs. of ice an hour. It is expected to cost $9,000, besides freight from Halle to Columbia, which is several hundred dollars more. It is to be operated by a steam engine of 3-horse power. The machine ordered is the largest made by the German manufacturers, who have 5 sizes, as follows: First, the one just mentioned; secondly, one costing $6,000, requiring a one-horse power steam-engine, and turning out 400 lbs. of ice an hour; thirdly, one costing $4,000 worked by hand, and turning out 200 lbs. of ice an hour; fourthly, one costing $2,700, worked also by hand, and turning out 100 lbs. of ice every hour; and fifthly, one which is the smallest size built by the firm, costing £1,500, worked by hand, and turning out 50 lbs. of ice every hour. The cost of manufacture, including labor and material, and using the largest machine, is estimated at 9 cents for 100 lbs. of ice. Last summer the regular price of ice in Columbia was 2½ cents a lb., and at retail 3 cents. A firm in Mobile is also said to be about to engage in the manufacture of ice the coming summer.

OCEAN TELEGRAPHY.—The London "Times," in an article on Ocean Telegraphy, says it is calculated that on an average a commercial message consists of 30 words. Sixteen words per minute is the rate at which a message can be transmitted and received by skilful operators, so that 30 messages can be sent in an hour. On account of the differences of time between distant parts of the earth, there can be no division of the 24 hours into day and night, and ocean cables must be worked continuously by relays of clerks. Still, in order to allow for the intervals between the conclusion of one message and the commencement of another, the day is considered to consist of only 20 hours; in which, therefore, 600 messages can be sent or received. At the present rate charged across the Atlantic these 600 messages of 30 words

each would bring in a return of £2,700; and thus, allowing 300 working days in the year, a single cable to America might earn a possible annual revenue of £710,000.

The business done already shows that the commerce between two centres of activity will pay for telegrams at a rate which will not only render the wires very remunerative property, but must also speedily lead to the adoption of such lower charges as will enable the system to be employed far more generally than it is at present. Indeed, when the returns from the lines have paid the original cost, and left a reserve fund for repair or replacement, there is no reason why business should not be done at exceedingly low rates, and so as to draw to the cable ordinary messages of domestic news, now consigned to the mails only. The entire length of ocean cables laid and in progress, excluding short lines, is 20,961 miles, and the capital stock engaged is £6,925,000.

England is at present dependent on Russia for telegraphic communication with India, and it happens in this wise: Russia constructed a line to her army in the Caucasus. This cost largely for maintenance, and the bright idea occurred that if the line could only be extended to India, the expense of its maintenance could be placed upon the broad shoulders of British commerce. The line was then constructed by the English from the termination of the Russian one, by way of Teheran and Tabreez to Bushire, and so through the Persian Gulf to Kurrachee. It was agreed that this line should pay a royalty of 40 per cent. on its receipts for the privilege of working through the Russian wires, and the result has been not only the dependence of Anglo-Indian telegraphy upon a foreign power, but also that British subjects have paid for the maintenance of the Russian line to the Caucasus, and that the Persian line, thus burdened, has returned to its British proprietors the modest dividend of 1.3 per cent.

Another Russian military line is across Siberia and Tartary, and on to this has been "tailed" a line to Posietta, on the Japanese Sea, whereon a company, "nominally Danish," is to lay a cable to Japan and to the Chinese ports. So Russia absolutely contrives to have the English business from China pass over her wires. The London "Times" does not like this, and so urges the completion of ocean lines, to take the place of these overland.—*The Telegrapher.*

Proposed Pacific Telegraph.—The Committee on Commerce has reported without amendments the bill to encourage telegraphic communication between the eastern and western hemispheres, or, in other words, the Pacific Cable Bill. The Bill provides that the starting-point for the cable shall be south of Cape San Juan, in Washington Territory. The line which the American and Asiatic Telegraph Company originally estimated, and to which substantially, we presume, they still adhere, was about 5,000 miles long. But the islands of the Pacific offer a great advantage in breaking this long line; and in this respect the enterprise is less hazardous, so far as the establishment of the line is increased, than its Atlantic predecessors. The distance from San Francisco to Cape San Juan, in Washington Tertory is 700 miles, and this part of the line is already made. There begins the ocean cable proper, which, proceeding north-westerly, finds its first station at Sitka, a distance of 630 miles. Thence, proceeding due west 500 miles, it touches Kodiak, where we have, or lately had, a military post. Thence, stretching south-westerly along the peninsula and the Aleutian group of islands 450 miles, it touches Oonalaska. From that point it leaves American islands behind, and 660 miles to the west reaches the island of Attou, and with 660 more, Urup, the latter on the Asiatic shore. Another stretch of 300 miles carries it to Hakodadi, in Japan, where its mission proper as an ocean cable may be said to end. But with a northerly move of 200 miles, it reaches Poseyat, where, on the mainland of Asia, it will connect with a branch, already built, of that great Russian overland route which continues to the mouth of the Amoor River. From Poseyat a southerly trend of 650 miles (also submarine) carries the cable to Nagasaki, whence an easterly branch may continue 600 miles to Yokohama, and a westerly one of 450 to Shanghai, the latter to connect with the East India Telegraph Company's line, so encircling the globe. These were the stations, we say, and these the distances estimated a year or more ago, and if they have been, or shall be slightly changed, it can only be in the way of improvement. Even as they are, it is clear that no distance between adjacent points in the long line is greater than 700 miles, which is a trifle in ocean telegraphy. And, again, it is clear that the strict trans-Pacific course—say from San Juan to Hakodadi, is 3,190 miles in length, while that from Sitka to Japan is only 2,490. It is evident that the project is perfectly practicable, and that it need not be long before we have daily news here in New York from Japan and China, as we have it now from England and California.—*New York Times.*

Feeding Steam Boilers.—A recent English invention for feeding steam boilers or generators with water by the use of an automatic apparatus, consists of a heating or boiling close vessel, into which the supply water is filled either hot or cold, by the mere flow or slight head of gravitation supply (without the necessity of a pump or other forcing apparatus) intermittently by a reverse siphon construction of pipe, with a regulating-valve open or allowed to open by a float falling when the water is low in the boiler or generator, and the force of the inlet water through the siphon and valve, until the feeding vessel is full, or nearly so, the water being then heated within the feeding vessel until the steam rises above or equal to the pressure of the steam within the boiler or generator, when the water would then flow or gravitate into its water-space through a pipe and valve connecting the lower part of the feeding vessel therewith.

Papier-Mache Church.—There is said to be a papier-maché church actually existing near Bergen, Germany, which can contain nearly 1,000 persons. It is circular within, octagonal without. The relievos outside, and statues within, the roof, the ceiling, the Corinthian capitals, are all papier-maché, veneered waterproof by a saturation in vitriol, lime water, whey, or the whites of eggs.—*Builder.*

It is found that a sheet of ice 32 in. thick affords a perfectly safe passage for infantry or horses, marching in single file, and for light carriages; with a thickness of 6 in. it will bear all sorts of wagons and cannon.